POWER PLANT ENGINEERING

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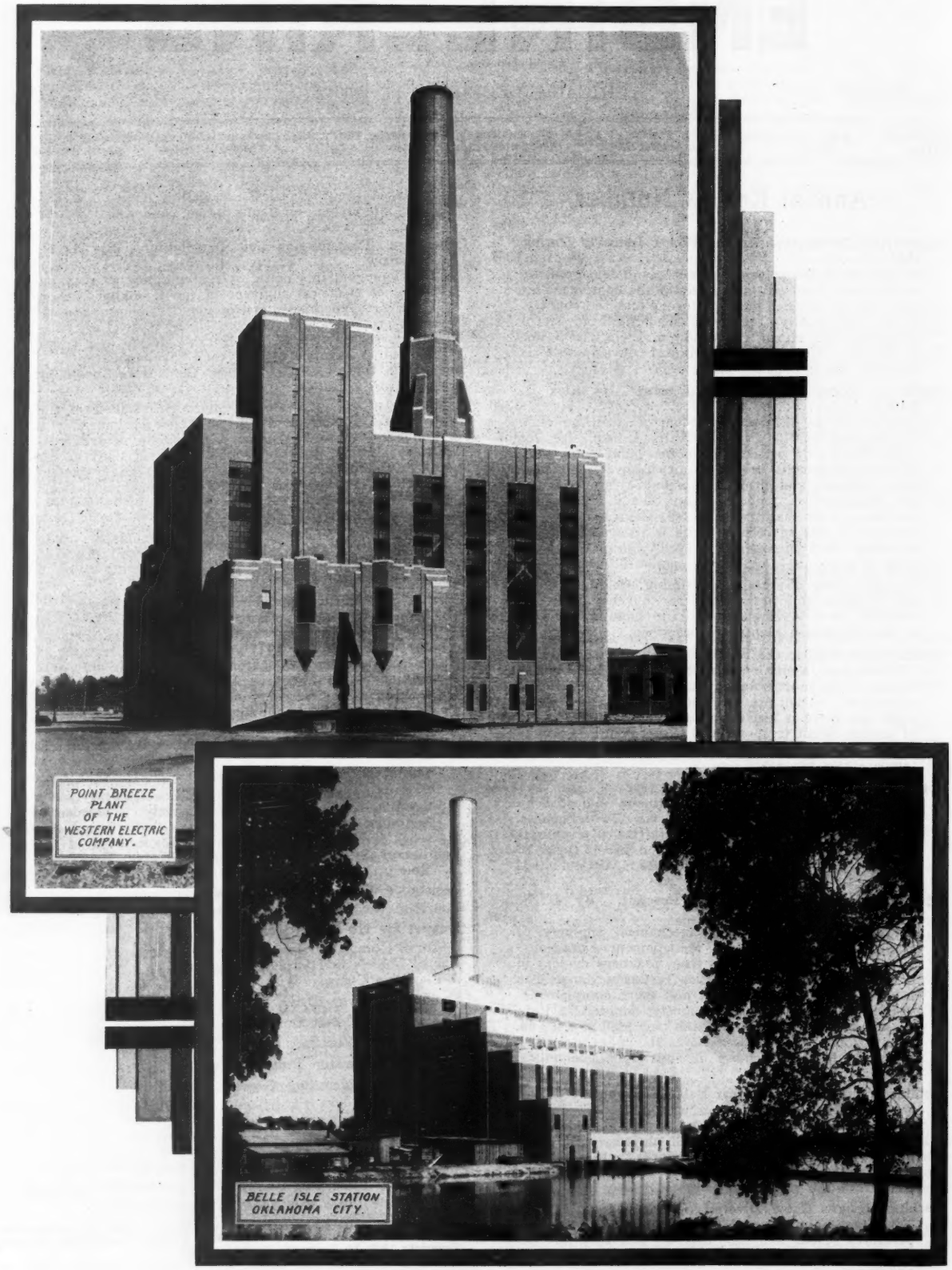
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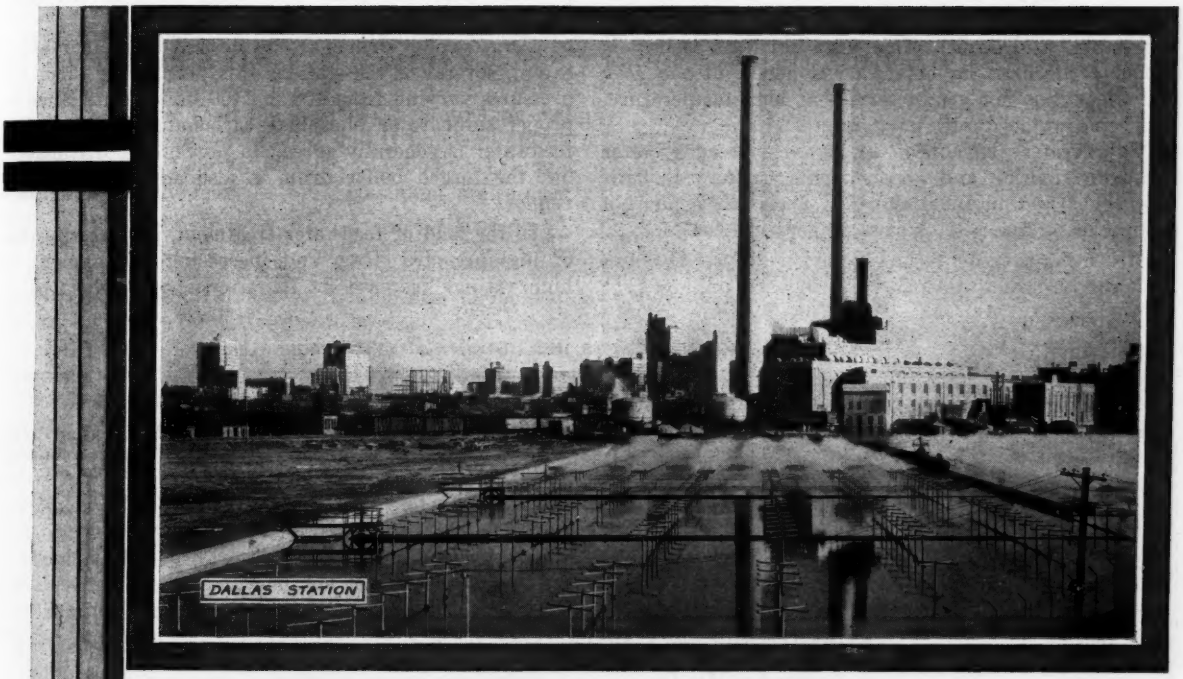


Engineering Developments *in the* Power Industry *during 1930*

IN A YEAR OF comparative quiet such as the one just past, when the major forces of the industry are not directed towards mere expansion of facilities, the purely technical and engineering developments are likely to show up rather prominently. There has been less of the spectacular in this year's development than was the case in the two preceding years—turbines have not been made larger, nor have boilers; neither have any new stations of such great magnitudes as State Line and East River and Hell Gate been started; more attention, however, has been directed towards securing greater economy in stations of smaller capacity.

As in previous years, the review of developments in the power plant industry presented in the following pages is based upon a study of the engineering features of a number of selected new plants and additions to new plants constructed throughout the year. Information drawn from this study has been supplemented with other data, taken from reports of various engineering organizations.

The plants included in this survey are fairly representative, approximately half of them being central station plants and the other half plants of the industrial class. The data presented on these plants was obtained by means of a direct questionnaire, and is as accurate as the owner's or designer's knowledge of their respective plants permits. Insofar as possible all data on equipment included in this survey is presented in such form as to permit of convenient comparison.

Steam Generation

As more experience is had with the operation and maintenance of equipment developed during the past few years, it is natural that the knowledge so gained will tend to modify somewhat the design and use of such equipment. In the boiler plant, for instance, there is a tendency especially in the high-pressure stations to reduce the amount of heating surface in the boiler proper and to put more of the heating surface in the water walls, economizers, superheaters and air preheaters, as at South Amboy, Deepwater and Concepcion stations.

Steam pressures have not increased materially over the 1300 and 1400 lb. values attainen several years ago and it does not seem as though any considerable advantages can be obtained by exceeding these

pressures. The tendency probably will be more toward the use of higher temperatures, rather than pressures, and the eyes of the entire industry are on the 1000 deg. installation at Detroit. This installation at Delray is probably the most important development of the year and while it is not yet in service at high temperature, it is being watched with great interest.

Superheaters have been improved to secure better steam distribution and higher temperatures with suitable alloys and in some cases, as at South Amboy, a desuperheater keeps the steam temperature constant.

Reheating is accomplished in various ways. At South Amboy both steam and gas reheating are employed, at Concepcion, steam reheat only and at Deepwater a new arrangement of thoroughfare and dead end reheater.

Slag tap furnaces continue to find application, water cooled walls are used widely not only with pulverized coal and stoker firing but with natural gas and oil firing as well. Turbulent burners for pulverized coal and combination gas and oil burners are in extensive use. Mill drying of pulverized coal seems firmly established and the rate of installation of unit mill systems seems to be increasing faster than that of central systems. Values of heat liberation in furnaces have increased somewhat. Station practice has seen no spectacular developments, but improvements have been made in many details of design and operation. Larger units and better control of air to various parts of the fuel bed characterize this development.

Progress in fuel handling practice this year has consisted mostly in the applications of devices and principles previously known. South Amboy presents the outstanding example of originality in its use of coal silos just outside the boiler room from which coal flows by gravity direct to the pulverizer feeders in the boiler room basement. This arrangement eliminates inside bunkers and keeps the boiler room clean, well lighted and well ventilated.

Methods of welding have progressed so rapidly that many engineers prophecy the acceptance of welding of pressure parts of steam generating units in the near future.

Forged boiler drums are being used to an increasing extent, several of the stations this year using them for pressures varying from 400 to 1400 lb. Maintenance of proper sulphate or phosphate carbonate ratio of boiler feedwater is generally agreed to prevent embrittlement, but the forged boiler drum is also advocated to prevent it.

In the field of feedwater treatment, the growing use of high-pressure steam and increasing employment of high ratings increase its importance and have led to much investigation during the past year. On the whole, we seem to be considerably closer to the solution of feedwater treatment than we were several years back.

LIST OF POWER PLANTS INCLUDED IN SURVEY

Name of Station	Owners	Location	Consulting Engineers
James H. Reed	Duquesne Light Co.	Pittsburgh, Pa.	Byllesby Engrg. and Management Corp.
Belle Isle	Oklahoma Gas & Electric Co.	Oklahoma City, Okla.	Byllesby Engrg. and Management Corp.
Rio Grande	El Paso Electric Co.	El Paso, Tex.	Stone & Webster Engineering Corp.
Shuffleton	Puget Sound Power & Light Co.	Renton, Wash.	Stone & Webster Engineering Corp.
Louisiana	Louisiana Steam Products Co.	Baton Rouge, La.	Stone & Webster Engineering Corp.
Atkinson	Georgia Power Co.	Atlanta, Ga.	Southeastern Engineering Co.
Great Western	San Joaquin Light & Power Corp.	San Francisco, Calif.	McClellan & Junkersfeld
Deepwater	Houston Lighting & Power Co.	Houston, Tex.	Houston Lighting & Power Co.
Dallas	Dallas Power & Light Co.	Dallas, Tex.	Dallas Power & Light Co.
Devil's River	Central Power & Light Co.	Del Rio, Tex.	Sargent & Lundy
Concepcion Road	San Antonio Public Service Co.	San Antonio, Tex.	
South Amboy	Jersey Central Power & Light Co.	South Amboy, N. Y.	Electric Management and Engrg. Corp.
Waldorf	Waldorf Paper Products Co.	Minneapolis, Minn.	Ralph D. Thomas
Atwater Kent	Atwater Kent Mfg. Co.	Philadelphia, Pa.	Ballinger Co.
Procter & Gamble	Procter & Gamble Co.	Baltimore, Md.	Procter & Gamble Co.
American Enka	American Enka Corp.	Asheville, N. C.	Lockwood Greene Engineers, Inc.
Calumet and Arizona	Calumet & Arizona Mining Co.	Lowell, Ariz.	W. W. Jourdin & Co., Inc.
William Wilheim	William Wilheim Co.	Passaic, N. J.	Henry R. Kent & Co.
Pt. Breeze	Western Electric Co., Inc.	Baltimore, Md.	H. K. Ferguson Co.
Bureau of Standards	Bureau of Standards	Washington, D. C.	
Proximity	Proximity Mfg. Co.	Greensboro, N. C.	J. E. Sirrine & Co.
University of Nebraska	University of Nebraska	Lincoln, Neb.	Burns & McDonnell
American Salpa	American Salpa Corp.	Spotswood, N. J.	American Salpa Corp.
Champion Coated Paper	Champion Coated Paper Co.	Hamilton, Ohio	Champion Coated Paper Co.
Titanium Pigment	Titanium Pigment Co.	St. Louis, Mo.	Titanium Pigment Co.

Steam Turbine Practice

In the conversion of steam energy into power, the importance of the 1000-deg. turbine installation at Delray has already been mentioned. This is the outstanding development of the year.

Second in importance to the country as a whole is the application of open heaters for extraction lines. Pressures of up to 800 lb. are being handled successfully through open heaters at South Amboy and if uniformly successful for general application may completely change the practice in a field where the closed heater has so far been supreme.

At South Meadow Station the mercury turbine has been giving a satisfactory performance and has to date turned out some 103,000,000 kw-hr. at approximately 10,000 B.t.u. per unit. Test results show 9800 B.t.u. per kw-hr. at the best point considering both the main equipment and its complement of steam equipment.

Substantial progress has been made by manufacturers in standardization of low and moderate pressure turbine equipment which will undoubtedly effect further savings in construction costs of low pressure stations or

rather in stations up to about 600 lb. Recent station practice, however, seems to indicate that the 600 to 900 lb. pressure range is not particularly attractive and that if the complication of reheat equipment necessary for these pressures is advisable it is best to go to 1200-1400 lb.

No unit larger than the 208,000-kw. State Line machine has been built or ordered and if numbers are an indication, the 160,000-kw. (or 200,000-kv-a.) single shaft units are the most desirable maximum size to meet present conditions.

One of these units for Hudson Avenue Station will be served by the largest single shell condenser yet contemplated. It is a 101,000-sq. ft. unit now under construction. Tubes 30 ft. long will be used and both the circulating and hotwell pumps will be driven by two speed motors.

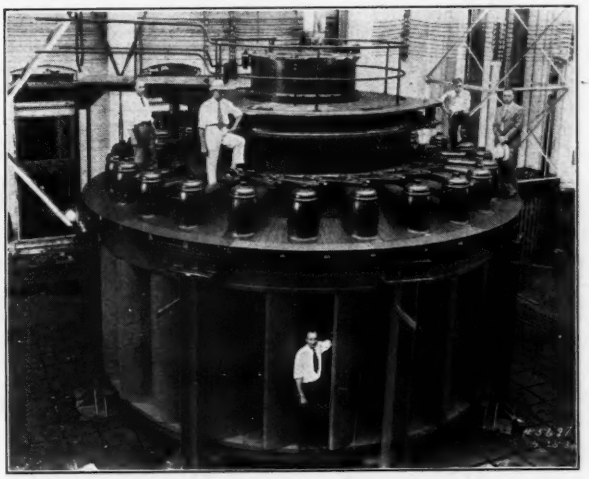
On the whole, auxiliary practice has been more or less standardized with two circulating and two hotwell pumps per unit. Electric drive has been practically universal for the past few years and the recent extensive development of the multispeed motor has done much to increase its flexibility without the added complications of the variable speed motor. Vertical circulating pumps are increasing in popularity and the three-stage steam jet vacuum pumps are being used extensively although the two-stage type still predominates.

Electrical Developments

Electrical developments made during the year include the application of the De-ion principle announced last year, to the oil circuit breaker, the production of the Thyrite lightning arrester, improvements in high voltage cable design, and the development of the miniature switchboard. The latter is an especially interesting development, involving the use of a new line of small instruments and switchboard accessories which make it possible to condense the circuit equipment which formerly required from 12 to 24 in. with a space some 6 or 8 in. wide.

Electric generator practice has undergone no marked changes, the largest units in use being in the neighborhood of 160,000 kw., the same as last year. While it seems perfectly feasible to build larger generators there seems no immediate need for them. Voltages used in generators are for the most part still between 11,000 and 14,000 v. although a few of the larger machines use 22,000 v. successfully.

Diesel power applications are extending rapidly and while there have been no startling new developments, this year's development has been characterized by many refinements in engine construction and in plant equipment. The use of large capacity Diesel units seems more pronounced in Europe than it does in the United States.

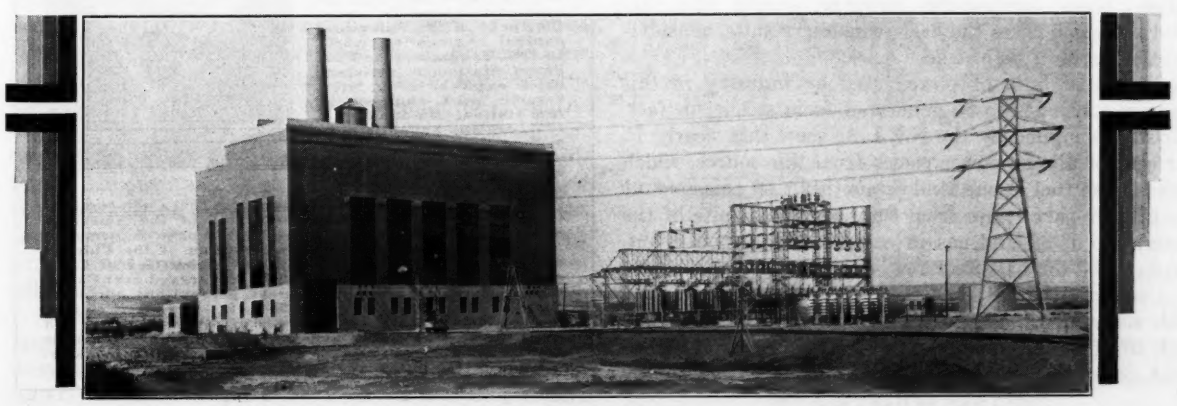


SHOP ASSEMBLY OF THE 57,000-HP. SPIERS HYDRAULIC TURBINE. THIS UNIT IS OF THE LARGEST PHYSICAL DIMENSIONS YET CONSTRUCTED

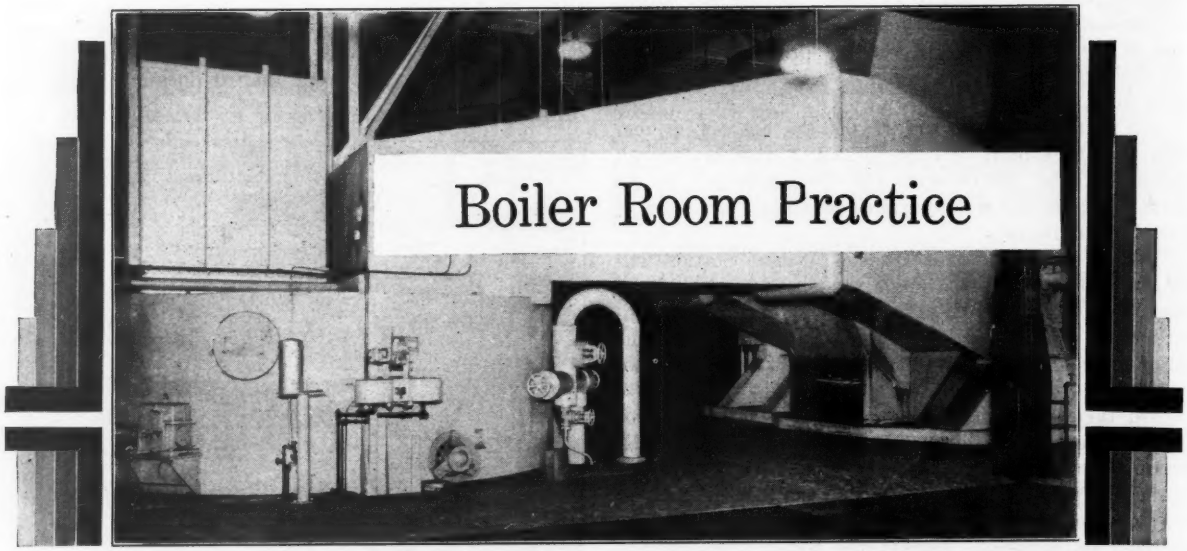
The size of hydraulic units has increased and new types of turbines have been evolved. For low head installations the adjustable blade propeller type turbine with its flat efficiency curve makes it possible to operate at relatively small gate openings, thus permitting the installation of much larger units for a given efficiency at minimum load than would be possible with reaction or fixed blade propeller type machines.

An extremely important development in hydroelectric practice is the increasing use of model tests. Not only have the facilities of many university and technical college hydraulic laboratories been increased and new ones constructed or projected, but some of the power companies also have constructed laboratories wherein results of great value have been obtained.

Experiments with the small scale model of the Spier Falls forebay and conduits resulted in the saving of a large amount of money in construction. The Spiers Falls turbine of 57,000 hp. capacity under an 81-ft. head is of the largest physical dimensions constructed to date. A shop view of this unit is shown on this page.



RIO GRANDE POWER STATION, EL PASO ELECTRIC CO.



Trends in Steam Generating Equipment

DEVELOPMENTS IN BOILER, FURNACE AND FIRING EQUIPMENT AND THEIR INFLUENCE ON COST. BY ALEX D. BAILEY

GOOD ENGINEERING is seldom spectacular and almost never sensational; developments and improvements are gradual and progress over a relatively short time may seem slow though the developments of a generation seem phenomenal. To attempt to recite the progress made in any branch of engineering in the short space of a year would be well nigh impossible without going into a maze of technical detail, which would be boresome, to say the least. The best we can do is to analyze and to record the trend which is taking place along certain definite lines.

Engineering is always a compromise of many governing factors and influences; cost, reliability, simplicity, efficiency, purpose, life and many others, the importance of each item depending on the particular conditions. All these can be evaluated in dollars and cents but another group comprising human life, health, comfort and happiness frequently enter the picture, outweighing all other considerations. These cannot be given a money value. Good engineering, however, should find that solution which gives the best economic results, considering that term in its broadest sense.

The great bulk of power used by industry in this country continues to be generated from steam; in fact, statistics compiled by the N.E.L.A. show that nearly 75 per cent of all the power comes from this source, which means from fuel of one kind or another. Of this amount the greater part comes from coal, which, in spite of the abundance of oil and gas in certain localities, still continues to be the base fuel for all purposes.

Compared with the cost of the fuel used annually, with maintenance cost and with operating labor cost or with all of these combined, the investment cost of equipment generating steam for power purposes from fuel is relatively high, which gives a particular slant to any problem of design. Fixed charges are high and everlasting, so original cost must be given first consideration, as a reduction in fixed charges is surer than a contemplated reduction in operating cost and its benefits are of immediate as well as lasting importance. The struggle, then, to reduce investment cost on the one hand and operating cost on the other becomes exceedingly

Alex D. Bailey, Superintendent of Generating Stations, Commonwealth Edison Co. and chairman of the Engineering National Section, N.E.L.A., was born in Wisconsin and has lived in Chicago since the age of seven. After graduating from Lewis Institute (Chicago), he worked for a short time for the Evanston Heating Co. and entered the employ of the Chicago Edison Co., (a predecessor of the Commonwealth Edison Co.) late in 1903, as mechanical engineer at the Harrison Street Station.

After 3 yr. at Harrison Street Station, he was transferred to the Engineering Department of the company, where he spent the next 2 yr. planning general engineering work. In 1906, he was sent to Fisk Street Station as assistant chief engineer and, later, became chief engineer of this station. On January 1, 1921, he was appointed superintendent of generating stations of the Commonwealth Edison Co., which position he now holds.

Mr. Bailey is a member of both the Test Code committee and the main research committee of the American Society of Mechanical Engineers and is past chairman of the Power committee and past chairman of the Chicago section of the Society. Among the committees of Commonwealth Edison Co. on which he has served are: Chairman, generating station; accident prevention; advisory; engineering; labor efficiency; 60-cycle system power factor and others. He is a member of other technical and scientific organizations and is the author of numerous articles on various phases of the electric utility industry.

interesting and while, under some conditions, a reduction in the former will result in a reduction in the latter, we more frequently find that the two work in opposition. Under the latter condition, all the opposing factors must be carefully weighed if the best result is to be obtained.

Increase in Size of Units

Centralization of power generation and the resultant continual increase in the size of steam generating units and auxiliaries has resulted in continually decreasing investment costs per unit of capacity and a similarly decreasing operating cost per unit of output; fuel, maintenance and labor costs have all been reduced. This explains the continually growing number of large steam generating units going into service each year. Under such favorable conditions, this trend is inevitable and it will continue until the investment factor or the operating factor changes. The million pound boiler has become a reality; in fact, one of the boilers in the East River station in New York has delivered 1,250,000 lb. of steam per hour for short periods. Dr. Munziger in reviewing the work of the recent World Power Conference in Berlin states that "Boiler outputs of from 2,000,000 to 2,500,000 lb. of steam per hour seem quite possible of attainment in the near future."

If the reliability of this equipment had not been steadily improving, such large units would be impossible and unheard of because of the excessive reserve that would be necessary. Simplicity of design has come into the picture to insure reliability and common sense has dictated that extraordinary thermal efficiency is not the object most to be desired. The increase in reliability and in size have gone hand in hand until the one boiler unit which has been dreamed of and talked of has become a reality and large installations are being designed and constructed without reserve boiler units. The increase in unit size is logical and the unit boiler idea is a natural sequence provided reliability is assured.

Water-Cooled Walls, Preheated Air, Feedwater Purification

Water-cooled furnace walls have established themselves as a standard part of any installation of reasonable size as they not only afford heating surface at reasonable cost but what is more, they obviate the outages for furnace cleaning and maintenance necessary with refractory-lined furnaces. This added reliability and continuity of operation have been large factors in making the large steam generating units possible. In addition, water walls have raised the limit of furnace temperature or removed it. As a result, preheated air temperature has increased until it has not only reached the limit which stokers can stand mechanically but has passed it and gone up to temperatures of 600 deg. F. and much higher temperatures are now being considered. Although preheated air may have been introduced with the idea of increasing furnace temperature, it has been found that there are other marked benefits, such as increased rates of combustion and increased furnace efficiency.

Another development which has made possible the large installations and the high capacities which are becoming so common has been the purification of feedwater. Volumes might be written on this subject and much remains to be found out regarding the action of water and its soluble content under high pressure and temperature but the fact remains that more is known about the subject of feedwater treatment today than ever before and the operating engineer can feel surer of the condition of his equipment and can avoid trouble more easily than ever before. The steam generated in modern boiler plants is now of such purity that when condensed it approaches absolute purity within limits much finer than engineers have been accustomed to consider. As a result, ideas regarding rates of heat transfer are being continually revised upward as it is found that with proper water conditions, heating surface may be subjected to the severest working conditions imaginable.

In the continual effort to reduce operating fuel costs, the trend for years has been to add auxiliary equipment of one kind and another, adding complexity and sacrificing simplicity for efficiency wherever the fuel saving would justify the additional fixed charges. Economizers, air preheaters and steam reheating installations have justified their place in boiler room design where load and fuel costs are favorable. In fact, they are playing an increasingly important part each year as steam pressure and temperature are increased and as feedwater temperature and air temperature follow suit.

Furnaces and Firing Equipment

The development of furnaces and firing equipment has also played a most important part in the development of large steam generating units. About the time it was conceded that stoker sizes had reached the limit because of mechanical difficulties, the advent of pulverized fuel practically removed the limit with regard to size. Advocates of stoker firing quickly accepted the challenge and there resulted not only an increase of stoker sizes but an increase in the reliability of per-

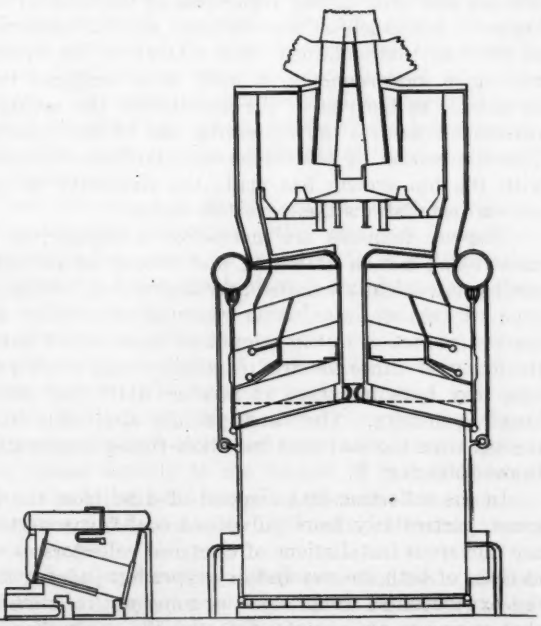


FIG. 1. RELATIVE SIZES OF A 500-HP. BOILER THAT WAS CONSIDERED LARGE 25 YR. AGO AND ONE OF THE PRESENT BOILERS REPORTED TO HAVE LARGEST HEATING SURFACE OF ANY BOILER BUILT. THE EARLY BOILER MADE 25,000 LB. OF STEAM AN HOUR AT AN EFFICIENCY OF LESS THAN 60 PER CENT

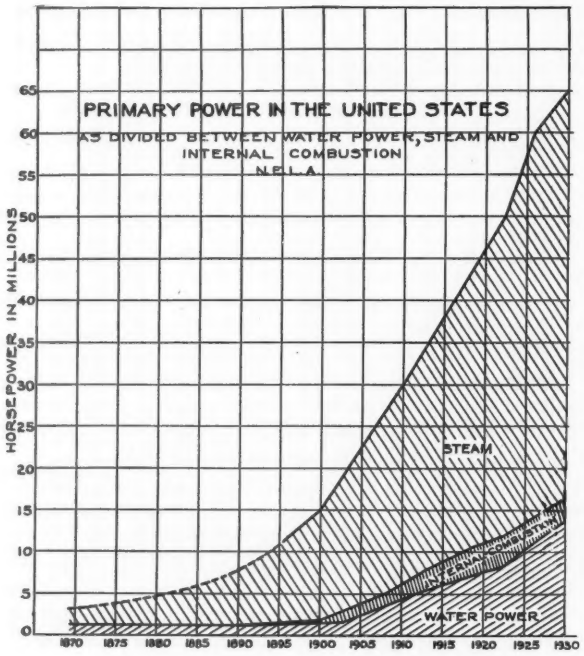


FIG. 2. PRIMARY POWER IN THE UNITED STATES

formance and efficiency until today we have boiler units fired with stokers developing 400,000 lb. of steam per hour. It is evident, however, that under existing conditions, pulverized coal firing has advantages and may be the only solution for the exceedingly large steam generating units now being built which will use coal for fuel.

So far as pulverized coal firing is concerned, a survey of recent installations shows a marked tendency to unit systems and mill drying regardless of the kind of coal burned. Inasmuch as the efficiency of unit systems is as good as that obtained with central or bin systems and since improvements in mills have rendered them as reliable as the rest of the installation, the saving in investment assures the increasing use of unit systems. The elimination of the numerous auxiliaries necessary with the bin system has made the simplicity of unit system installations their greatest virtue.

Slag-tap furnaces are increasing in number, as the molten slag can be drawn off and broken up so that it can be conveniently handled and disposed of. With this type of furnace, also, it is reported that there is a marked reduction in the amount of dust carried out by the flue gas. Since the first installation only a few years ago, they have increased in number until they are no longer a novelty. They are specially applicable where the ash from the coal used has a low fusing temperature, below 2500 deg. F.

In the collection and disposal of dust from the flue gases, particularly from pulverized coal furnaces, there are numerous installations of electrical collectors as well as those of both the wet and dry types but judging from the experimental work which is going on, it is evident that engineers are not satisfied with the equipment now offered, for one reason or another, and that a very definite effort is being made to get a better job done at a reasonable cost. The elimination of sulphur in the flue gases is also coming in for considerable attention, urged on by the interest of the general public in air pollution, as evidenced by the trouble recently experienced in England.

Steam Pressures and Temperatures

The increase in steam pressure and temperature has followed the same logical line of development. Increased pressure has generally meant increased unit cost and where this overbalanced the operating saving, progress stopped. At the present time 1500 lb. seems to be the economic limit, unless changes in boiler design alter the situation. In view of the small gain in thermal efficiency as pressures are increased above 1500 lb. and in view of the probable increased cost of steam generating equipment for higher pressures, the trend of station design will undoubtedly be toward higher steam temperature as this offers greater possibilities for improved efficiency. Further increase in steam temperature with its resultant savings in operating cost, however, seems temporarily halted or retarded because of the inability to find metals that will stand up under this service. The newest equipment now being built in large sizes has a limiting steam temperature of 850 deg. F. but the success of the 1000 deg. F. experiment of the Detroit Edison Co. leads us to believe that by increasing steam velocities, and assuring proper distribution of steam flow, superheaters may be built for higher steam temperatures than those now considered the limit. Steam temperatures, however, are approaching so closely to the safe temperature of the metals available for superheater construction that great care must be taken to avoid variations in steam flow such as might result from a decrease in feedwater temperature due to the temporary outage of a heater in the feedwater heating system, or to irregular feedwater supply. Provision may have to be made for automatically controlling steam flow through the superheater to avoid overheating of the superheater itself.

As steam pressure and temperature are increased, possibilities for the economical utilization of the steam are likewise increased so that we find this feature of particular interest to industries requiring steam both for power and process work. In power stations, high initial steam temperature offers the possibility of complete expansion without reheating, which always involves additional and sometimes excessive investment costs.

Automatic Control and Instruments

In the matter of automatic control, the lad who, with the early steam engine, connected the hand operated steam valves to the revolving part of the engine so that their operation would be automatic was the prototype of all engineers past and present. No engineer would admit that this desire to have everything operate automatically is due to laziness but it seems to be an inherent characteristic, nevertheless. While it may be true that the savings incident to automatic operation of furnaces and boilers in any one particular direction may be slight, there should be a gain in the overall performance, all things considered. This thought encourages both operators and designers to persist in the search for proper automatic equipment. As in the past, the tendency will be toward automatic control and though the progress may be slow, it will be none the less sure.

The use of instruments has become such standard practice and their importance is so well appreciated that little need be said. These are being improved along

with the rest of the auxiliary apparatus connected with the main unit. In spite of the dismal forebodings of the past, they have earned their place as a reliable and necessary part of boiler room equipment.

Some may claim that the economic limit for steam pressure has been passed, possibly for steam temperature also, but the growing number of large installations with higher pressures and the gradual increase in steam temperature disprove this claim. It must be admitted, however, that with present types of construction we have about reached the limit and that decreasing gains in the efficiency of the present steam cycle will be obtained with increasing cost. Shall we expect that there will be radical changes in the design of steam generating equipment or will the next step be in the direction of a binary cycle on which a great deal of work has already been done and which offers plenty of opportunity for the ambitious and imaginative engineer? From the past history of engineering as a whole, we know that the art of power generation from fuels will not stand still. The developments of the past should be a promise of what the future holds in store.

Progress in Storing and Handling Fuel

CONSIDERATIONS OF STORAGE, RECLAIMING EQUIPMENT, STORAGE BUNKERS, PREPARATION FOR BURNING, WITH OUTSTANDING EXAMPLES

IT IS OBVIOUSLY difficult to discover any definite trends throughout the power plant industry in the various methods of handling fuel. Every engineer knows how many independent variables are involved in the selection of fuel handling equipment for a given plant: fuel available, necessity for storage as affected by seasonal variations, type of service the station is to render, fuel storage space available, type of fuel burning equipment and interior arrangement of station and, of course, fixed charges and operating charges on the equipment and many other factors. With these variables in mind, our purpose in presenting a tabulation of fuel handling equipment in this review is to show the wide variation in methods and equipment used. The fuel handling equipment in any station is an important element in its design and operation and in connection with the data given in this issue on 25 of the outstanding plants of the year, their fuel handling arrangements should be of interest.

Study of the table herewith shows that in most cases coal burning plants receive their fuel by rail. James H. Reed station, however, receives all its coal by water and South Amboy receives it by rail but is equipped to handle it when it comes by water. Of the plants burning oil, Shuffleton receives oil by ocean tankers, some of the others by rail in tank cars and Louisiana plant receives fuel oil and refinery residuals direct by pipe line from the neighboring oil refinery to which it supplies power plant services.

For storing and reclaiming coal in the storage space, six of the 15 coal burning plants employ drag scrapers. Coal is usually crushed in preparation for burning; in some cases, where it is burned in pulverized form, it is crushed before pulverizing, depending to some extent on the type of fuel used.

One of the encouraging signs of the times, symbolizing the increased interest of the industrial power plant in determining its performance, is the column in the table showing how fuel is measured.

DISPOSAL OF ASH

Ash disposal from the furnace is by sluice in several cases, in others by truck or industrial car or railroad. In many cases, soot hoppers are provided in breechings, at the bottom of economizers and air preheaters and sometimes at the last pass of the boiler, to collect soot and dirt deposited by the flue gas. Ducts from these hoppers lead to the ash disposal system in many cases, so that the soot can be handled conveniently.

At Champion Coated Paper Co., dust from the flue gas, removed by stack sprays is led by a chute down to a water chamber where it settles and is removed by a small grab bucket loading to industrial cars that remove it from the plant.

An interesting installation of dust collectors is installed at the Atwater Kent plant as described in the Nov. 1 issue of Power Plant Engineering. This plant serves a large factory located near residential districts and the desirability of preventing pollution of the atmosphere around the plant led to the use of the collectors. More and more cities are adopting regulations regarding the pollution of the air by discharges from chimneys and this fact is making the subject important for the power engineer.

Of all the coal handling equipment installed this year, that at South Amboy has probably attracted most attention because of its original ideas and the unusual way in which it has employed silos instead of inside bunkers. The essential feature of this scheme is that all coal is stored outside the walls of the boiler room, eliminating much interior steelwork and giving a light, airy boiler room.

Coal is received at South Amboy either by rail or water and after unloading either by track hopper or barge unloading tower, is raised by a skip hoist to a coal breaker. After it is broken, it can discharge either to a storage space (to be stored and reclaimed by a drag scraper) or direct to a horizontal belt conveyor. The belt conveyor takes it to six reënforced concrete storage silos, of 125 t. capacity each, standing just outside the boiler room. From these silos, the coal flows by gravity through chutes, directly onto weighing devices, thence directly to the feeders of the pulverizing mills in the boiler room basement. Details of this scheme were given in the July 15, 1930 issue of Power Plant Engineering.

Another coal-handling installation that has attracted considerable attention is the system at Pt. Breeze plant of the Western Electric Co. Here a storage yard (at present storing about 36,000 t.) is provided, in which coal is stored and reclaimed by a drag scraper. This scraper is under the control of an operator who sits in a bay window built out on the side of the boiler room wall. Thus he is at all times aware of events in the

FUEL STORAGE AND HANDLING

STATION	TYPE OF FUEL AND SOURCE	HOW RECEIVED	METHOD OF BURNING	AVERAGE OUTSIDE STORAGE TONS FUEL OIL-GAL.	MAXIMUM DEPTH OF STORAGE PILE	UNLOADING EQUIPMENT	STORAGE AND RECLAIMING EQUIPMENT	PREPARATION FOR BURNING	CONVEYORS TO BOILER HOUSE BUNKERS	BLR. HOUSE BUNKERS CAPACITY TONS	HOW IS COAL WEIGHED OR MEASURED	ASH DISPOSAL
JAMES H. REED	PENNA. BIT.	WATER	U.F. STOKERS	250000 T. MAX.	30 FT	BARGE UNLOADING TOWER	DRAG SCRAPER	CRUSHER	BELT	300 T. PER BOILER	IN CARS	SLUICE
BELLE ISLE	NATURAL GAS	———	———	———	———	———	———	———	———	———	———	———
RIO GRANDE	GAS & OIL	GAS BY PIPE LINE OIL BY TANK	COMBINATION OIL & GAS BURNERS	420,000 GAL FUEL OIL	———	———	———	———	———	———	———	———
SHUFFLETON	OIL	OCEAN TANKERS	OIL BURNERS	2,520,000 GAL.	———	———	———	———	———	———	———	———
LOUISIANA	■ REFINERY RESIDUALS	GAS—PIPE LINE COKE—RR CARS OTHERS PIPED FROM REFINERY.	COMB. GAS & OIL BURNERS PULV. FUEL BURNERS	4000 GAL. FUEL OIL 4500 GAL. RESIDUALS	COKE DELIVERED AS REQUIRED	FOR COKE TRACK HOPP'R		COKE CRUSHER & PULVERIZING MILLS	INCLINED BELT	320 T. COKE	AUTO. SCALES FOR COKE	———
ATKINSON	BIT. COAL	RAILROAD	PULVERIZED	50,000	30 FT.	COAL HOPPER	DRAG SCRAPER	200 TON PER HR CRUSHER 1" & SMALLER	DRAG SCRAPER OR TRACK HOPPER TO BELT CONV. TO BUNKERS 200 TONS PER HR	800	WEIGHING DEVICE ON BELT CONV.	SLUICE
GREAT WESTERN	OIL & GAS	OIL BY BARGE GAS BY PIPE	COMB. OIL & GAS BURNERS	37,500 BBL. TANK	———	OIL PUMPED FROM BARGE GAS FROM FIELDS BY PIPE LINE	———	———	———	———	OIL MEASURED FROM TANK GAS BY METER	———
DEEPWATER	NAT. GAS & OIL	———	———	———	———	———	———	———	———	———	———	———
DALLAS	NAT. GAS & OIL	———	———	———	———	———	———	———	———	———	———	———
DEVILS RIVER	NATURAL GAS OIL AS AUX.	———	———	———	———	———	———	———	———	———	———	———
CONCEPCION ROAD	OIL OR NATURAL GAS	OIL BY RAIL	COMBINATION BURNERS	OIL-1,500,000 GAL.	———	PERMANENT PUMP WITH FLEXIBLE HOSE TO CARS	———	HEATERS AT STORAGE TANK AND I AT BURNERS	———	———	———	———
SOUTH AMBOY	BITUMINOUS COAL	WATER OR RAIL	PULVERIZED	25,000	———	COAL TOWER TRACK HOPPER	DRAG SCRAPER	BREAKER	BELT	6 SILOS OUTSIDE BOILER ROOM 125 T. EACH	WEIGHING DEVICES ON AHEAD OF PULVERIZER FEEDERS	SLUICE
WALDORF	EASTERN BIT. SCREENING	RAIL	PULVERIZED	———	———	DUMP CAR TO TRACK HOPPER	———	———	TRAM CAR	1000	WEIGH LARRY	IND. CARS TO SKIP HOIST TO BUNKERS TO RY. CARS
ATWATER KENT	SEMI-BIT.	RAIL	PULVERIZED	———	———	HOPPER TO BUCKET ELEV.	———	CRUSHER & PULVERIZER	BUCKET ELEV. & FLIGHT CONV.	520	AUTO. SCALE	SLUICE
PROCTER & GAMBLE	W.VA. BIT.	RAIL	U.F. STOKERS	2,000	12	TRACK HOPP'R DRAG SCRAPER SKIP HOIST	DRAG SCRAPER	CRUSHER	HOPPER OR SCRAPER TO APRON. CONV. TO SKIP HOIST TO BUNKER OR STORAGE	275	WEIGH LARRY & CARS	CAR TO SKIP HOIST TO BIN TO CAR ON TRUCK
AMERICAN ENKA	BIT. COAL	RAIL	U.F. STOKERS	6000	15	DUMPER ELEVATOR DRAG SCRAP'R	DRAG SCRAPER	CRUSHER	———	900	IN CARS & OUT SCALE	SLUICE & TRUCKS
CALUMET & ARIZONA	CALIFORNIA FUEL OIL	RAIL	OIL BURNERS	13000 GAL.	———	———	———	———	———	———	———	———
WILLIAM WILHEIM	NO. 2 OR 3 BUCKWHEAT	TRUCK	C.G. STOKERS	50 T.	6	———	IND. CARS TO ELEV.	———	STM. HYD. ELEV. TO STOKER EXTENSION HOPPER LEVEL	———	TRACK SCALE	IND. RY. & EL. TO DUMP SOLD & REMOVED BY TRUCK
PT. BREEZE	BIT. R.O.M.	RAIL	U.F. STOKERS	36000 T.	2	TRACK HOPPER SKIP HOIST	DRAG SCRAPER	CRUSHER	DRAG SCRAPER TO HOPPER TO SKIP TO	480	TRACK SCALE	SLUICE TO SUMP. PUMP TO C.I. TANK TO
BUREAU OF STANDARDS	W.VA. BIT. SLACK	TRUCK FROM GOVT. YARD	PULVERIZED	CENTRAL FUEL YARD FOR		ALL GOVT. ESTABLISHMENT		NO CRUSHING REQUIRED	DIRECT TO BUNKER	400	SCALES	STM. JET TO BUNKER TO TRUCKS
PROXIMITY	NUT & SLACK	DUMP BOTTM. CARS	PULVERIZED	300000 T.	40	RAILROAD TRESTLE	———	———	GRAVITY	2000	AUTO. DEAD WEIGHT SCLS.	SLUICE
UNIVERSITY OF NEBRASKA	KANS & OKLA R.O.M.	RAIL	U.F. STOKERS	3000 T	20	TRACK HOPPER LOCO. CRANE	CRANE	———	SKIP HOIST	150	WEIGH LARRY	CARS
AMERICAN SALPA	PA. & MD. R.O.M.	RAIL	U.F. STOKERS	500	10	TRACK HOPPER	TRAVELING CRANE	CRUSHER	BUCKET ELEVATOR	175	SCALES AT BUNKERS	TRUCKS
CHAMPION COATED PAPER	BIT. W.VA. & E.KY.	RAIL	PULVERIZED	———	———	———	———	CRUSHER	VERT. BUCKET	4050	AUTO. SCALES	IND. CARS
TITANIUM PIGMENT	ILL. COAL	RAIL	C.G. STOKERS	———	———	TRACK HOPPER	BUCKET ELEV. SCRAPER CONV. OVER BUNKER	———	SCRAPER	———	AUTO. SCALES	HOPPER TO CARS

■ NATURAL GAS; PULV. CRUDE STILL COKE; PULV. CRACKING STILL COKE; FUEL OIL; LUBRICATING SLUDGE; NEUTRALIZED SLUDGE; ACID TAR; WAX TAILINGS; SODA BOTTOMS.

boiler room and can also control the other equipment elevating coal to the bunkers.

Coal reclaimed from the storage yard by drag scraper or unloaded direct from cars to the track hopper is raised by a skip hoist to the top of a tower at one end of boiler house.

For plants burning natural gas and oil, the problems of handling fuel are in some cases much simpler than in handling coal. Natural gas is usually received by these plants from pipe lines and fuel oil comes by barge or tank car. In the latter case, fuel oil is pumped and handled in the usual way. Only one of the stations tabulated, Concepcion, reports the use of fuel oil heaters. Heating is the usual practice, however, where necessary to make the oil flow properly or to maintain a definite viscosity.

Trends of the Year in the Boiler Room

LARGER UNITS, HIGH PRESSURES AND TEMPERATURES, INCREASED USE OF WATER WALLS, TREND TO UNIT MILLS AND MILL DRYING, IMPROVEMENTS IN DETAILS OF BOILER AND FIRING EQUIPMENT ARE FEATURES

AS MR. BAILEY has already pointed out, one of the most notable trends in steam generating equipment is the increase in size or capacity of units. This has been brought about in part by the desirability or necessity of reducing investment per unit of capacity and also by the increased reliability of the boiler, furnace and firing equipment that permits operation over comparatively long periods without the need for large reserve capacity.

This subject has been discussed frequently by engineers, especially the feasibility of installing one steam generating unit to serve one power generating unit with possibly one spare unit for the plant. This has actually been done at the plant of Champion Coated Paper Co., where a 27,192-sq. ft. boiler fired by pulverized coal, maximum capacity 343,000 lb. steam an hour serves a three-element turbine generator, an old boiler plant serving as reserve capacity. Also the arrangement at South Amboy follows this scheme, as there are two turbines, normally served by one boiler each, although a third boiler is installed and space left for a third turbine generator. At Bremo Bluff plant two tandem-compound units are served by two boilers. Incidentally, the boiler at Champion Coated Paper Co. is stated to be the largest single steam generating unit fired by unit pulverizers.

Most of the units represented in the accompanying tables are not, of course, the largest in existence or the largest installed this year. One of the steam generating units of the New York Edison Co. has been operated at 1,250,000 lb. of steam an hour. Work is proceeding on the 1200-lb. steam generating units to serve the 110,000-kw. vertical compound turbines of the Ford Motor Co. Each of these units is designed to make 700,000 lb. of steam an hour, fired by pulverized coal.

HIGHER STEAM PRESSURES AND TEMPERATURES

Typical of the trend to higher steam pressures are the Deepwater, Concepcion and South Amboy stations shown in the tabulations. It is notable that in these cases, the amount of heating surface in the boiler proper is comparatively low, thus reducing the cost of drums but this is offset by the larger amount of surface in water-cooled furnace walls, economizer, air preheater and superheater.

These three stations also illustrate current practice in reheating, discussed in more detail in the section of this review devoted to the heat balances of the stations. The arrangement at South Amboy consists of a steam reheater and a gas reheater in series, the combination designed to heat 226,000 lb. of steam an hour from 520 to 750 deg. F. At the Concepcion station a steam reheater only is used. Deepwater employs for reheating an arrangement of thoroughfare heaters and dead-end heaters shown in detail in the heat balance diagram elsewhere in this issue. This is believed to be a new idea in reheaters.

While the steam temperatures shown in the table seldom go much above 750 deg., except for Concepcion where the total steam temperature is 810 deg., there seems to be a general feeling that the upper limit of temperature will soon be increased to well above 800 deg.

The experiment of Detroit Edison Co. with steam at 1000 deg. is being watched with great interest and will doubtless lead to a general acceptance of higher temperatures. Bremo Bluff station is designed with the possibility in mind of raising the steam temperature later from 750 to 850 deg.

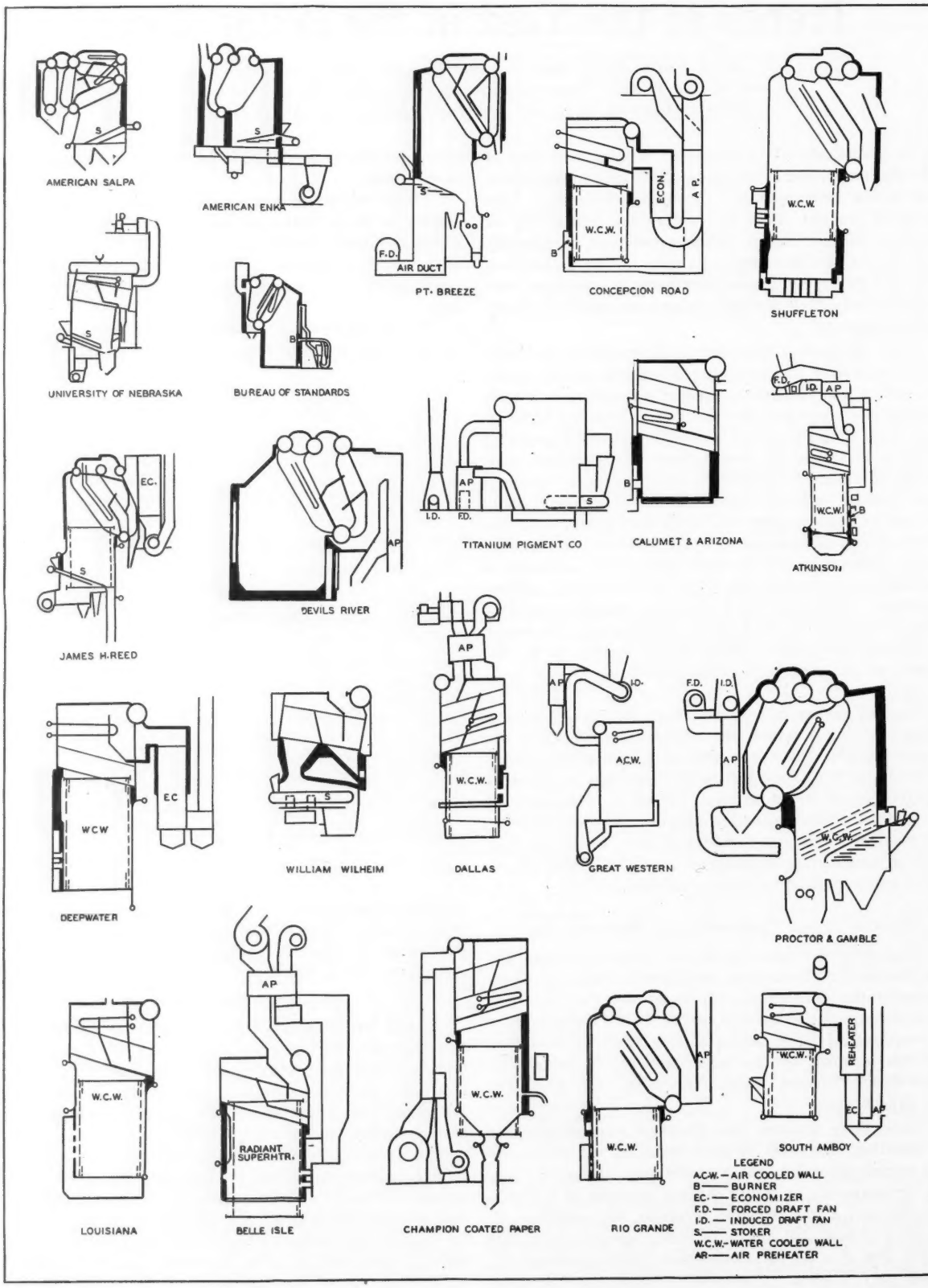
FANS

STATION	FORCED DRAFT TYPE	FORCED DRAFT NO. PER BLR.	FORCED DRAFT CAP. EACH C.F.M.	FORCED DRAFT CAP. TOTAL C.F.M.	FORCED DRAFT DRIVE	FORCED DRAFT STATIC PRESS IN. H_2O	INDUCED DRAFT TYPE	INDUCED DRAFT NO. PER BLR.	INDUCED DRAFT CAP. EACH C.F.M.	INDUCED DRAFT CAP. TOTAL C.F.M.	INDUCED DRAFT DRIVE	INDUCED DRAFT STATIC PRESS INCHES H_2O	CHIMNEYS NO. BLRS PER CHIMNEY
JAMES REED	TURBOVANE	2	83,300	166,600	AC. 2 SPEED MOTOR	6.0	TURBOVANE	2	127,000	254,000	AC. 2 SPEED MOTOR	8.0	3
BELLE ISLE	TURBOVANE	1	55,000	55,000	2 SPEED SQ. CAGE IND. MOTOR S	9.5	TURBOVANE	1	105,000	105,000	2 SPEED SQ. CAGE IND. MOTORS	7.0	3
RIO GRANDE	VANE CONT. TURBOVANE	1	75,000	75,000	A.C. MOTOR	9.0	VANE CONT. TURBOVANE	1	130,000	130,000	HIGH & LOW SPEED A.C. MOTORS	7.0	1
SHUFFLETON	VANE CONT. TURBOVANE	2	57,000	114,000	A.C. MOTOR	8.2	VANE CONT. TURBOVANE	2	135,000	270,000	A.C. MOTOR	10.25	1
LOUISIANA	RADIAL FLOW DBL. INLET	1	109,000	109,000 AT 100°	NON COND. STM. TURB.	11-2	RAD. FLOW DBL. INLET	2	84,000 AT 100°	168,000	NON COND. STM. TURB.	10-3	1
ATKINSON	SUPER TURBOVANE WITH LOUVER DAMPERS	1	150,000	150,000	2 SPEED 3 LINE SQ. CAGE MOTOR	14.0	SUPER DUPLEX WITH LOUVER DAMPERS	1	256,000	256,000	2 SPEED 3 LINE SQ. CAGE MOTOR	12.01	1
GREAT WESTERN	MULTI-BLADE	2	65,000	130,000	A.C. MOTOR	8.0	MULTI-VANE	1	250,000	250,000	DUAL DRIVE A.C. MOTOR	3.6	1
DEEPWATER	RADIAL FLOW	2	55,000 AT 100°	110,000	2 SPEED IND. MOTOR	11-8-	RADIAL TYP.	2	105,000 450°	210,000	2 SPEED IND. MOTOR	15.0	2
DALLAS	TURBOVANE	2	45,000	90,000	13 SPEED IND. MOTOR	8.0	MULTIVANE	2	60,000	120,000	2 SP. POLE CHANGING IND. MOTOR	8.0	2
DEVILS RIVER	CONOIDAL	1	30,000	30,000	VAR. SPEED A.C. MOTOR	3	CONOIDAL	1	50,000	50,000	VAR. SPEED AC. MOTOR	5.0	3
CONCEPCION	DAMPER CONTROLLED	1	70,000 AT 110°	70 000	CONST. SPD. IND. MOTOR	11	DAMPER CONTROLLED	1	110 000 AT 410°	110 000	CONST SPD. A.C. MOTOR	13.0	1
SOUTH AMBOY	TURBOVANE	2	40 000	80 000	VARIABLE SPEED A.C. MOTOR	8	INTEGRAL WITH VENTURI STACK	2	62 000	124 000	VARIABLE SPEED A.C. MOTOR	9.5	1
WALDORF		1	—— INTEGRAL		WITH PULVERIZER ——		STEEL PLATE	1	73,000	73,000	A.C. MOTOR	8.0	1
ATWATER KENT	CONOIDAL	1	28,800	28,800	VAR. SPEED A.C. MOTOR	6.5	CONOIDAL	1	42,800	42,800	VAR. SPEED A.C. MOTOR	9.2	1
PROCTER & GAMBLE	TURBO CONOIDAL	1	25 000	25 000	STEAM TURBINE	8.0	TURBO	1	33 500	33 500	TURBINE	8.0	1
AMERICAN ENKA	TURBO CONOIDAL DBL. INLET	1/2	55 000	55000	SYNCHRON'S MOTOR	8	——	——	——	——	——	——	4
CALUMET & ARIZONA	DOUBLE TURBO FAN	1 2	50 000 20 000	90 000	TURBINE IND. MOTOR	3-0	BOOSTER	1	——	——	IND. MOTOR	——	1
WILLIAM WILHELM	CONOIDAL	1	27,500	27,500	STEAM TURBINE	9	VENT STACK WITH FANS	1	55,920	55,920	STEAM TURBINE	2.5	1 ∗
PT. BREEZE	TURBOVANE	2	35 000 30 000	65 000	2 SPEED A.C. MOTOR	5.0	——	——	——	——	——	——	4
BUREAU OF STDS.	——	——	——	——	——	——	——	——	——	——	——	——	4
PROXIMITY		1	125,000	125,000	VAR. SPEED MOTOR	8-0		1	175,000	175,000	VAR. SPEED MOTOR	11.1	2
UNIVERSITY OF NEBRASKA	TURBOVANE	1	28 000	28 000	VAR. SPEED MOTOR	6	CONOIDAL	1	69 000	69000	VAR. SPEED MOTOR	9.5	2
AMERICAN SALPA	MULTIVANE	1	16 000	16000	1 STM. DRIVEN 1 VAR. SPEED MOTOR	8.0	MULTIVANE	1/2	69 000	69000	A.C. MOTOR	——	1
CHAMPION COAT. PAPER	MULTIVANE	1	——	——	VAR. SPEED A.C. MOTOR		STEEL PLATE	1	——	——	VAR. SPEED A.C. MOTOR	——	1
TITANIUM PIGMENT	——	1	——	——	MOTOR	——	INTEGRAL WITH VENT STACK	1	71 000	71 000	MOTOR	——	1

DESIGN OF SUPERHEATERS

Recent improvements in design of superheaters indicate that they will give satisfactory service and manufacturers will guarantee them for temperatures up to 850 deg. Such superheaters are similar in design to the single pass superheaters, a number of which have been installed during the past year.

Superheater design in general has been improved to reduce pressure drop and to distribute the steam more equally through the tubes. Headers are usually placed well outside the path of the hot gases; in some cases, the headers are entirely outside the boiler setting. The radiant superheaters in the furnace at Belle Isle station is the only one of its type noted on the tabulation, all the others being convection type. According to the Prime Movers Committee of the N.E.L.A., however, "the


AMERICAN SALPA
AMERICAN ENKA
PT. BREEZE
F.D.
AIR DUCT
CONCEPCION ROAD
W.C.W.
ECON.
A.P.
SHUFFLETON
UNIVERSITY OF NEBRASKA
BUREAU OF STANDARDS
TITANIUM PIGMENT CO
I.D.
F.D.
CALUMET & ARIZONA
ATKINSON
JAMES H.REED
EC.
DEVILS RIVER
WILLIAM WILHEIM
DALLAS
GREAT WESTERN
A.C.W.
PROCTOR & GAMBLE
DEEPWATER
WCW
LOUISIANA
RADIANT SUPERHTR.
BELLE ISLE
CHAMPION COATED PAPER
RIO GRANDE
REHEATER
SOUTH AMBOY
LEGEND
A.C.W. — AIR COOLED WALL
B —— BURNER
EC. —— ECONOMIZER
F.D. — FORCED DRAFT FAN
I.D. — INDUCED DRAFT FAN
S —— STOKER
W.C.W. — WATER COOLED WALL
AR —— AIR PREHEATER

practice of placing the superheaters closer to the fire instead of protecting them by placing the coils above the lower boiler tubes, is gaining favor. In many cases, the superheater coils are exposed to the fire, while the superheater headers are constructed back of the furnace walls."

In some cases, especially where resuperheaters are used, desuperheaters of the submerged type are used to maintain the steam temperature at a constant value, as at South Amboy.

Economizers and Air Preheaters

Economizers of both water and steaming types are used in some of the stations tabulated. As noted above, in some of the high pressure steam generating units, the tendency is to reduce the amount of heating surface in the boiler proper and to put more of it into the water cooled furnace walls and into economizer and air preheater. In some cases the temperature of water leaving the economizer is well over 500 deg. at maximum boiler output, especially with the 1400 lb. stations; at the 635 lb. Louisiana station it is 438 deg. while at James H. Reed, 415 lb. pressure, it is 393 deg. None of the industrial plants tabulated have economizers, except Waldorf where the heater section of the boiler performs the function of an economizer and American Salpa, where the rear section of boiler tubes is designed to act as an economizer.

Air preheaters are installed in most of the central stations and in many of the industrial plants tabulated. Usually one air preheater per boiler is used, the capacities ranging from about 15,000 lb. of air an hour to 520,000 lb. per hr. for a unit. Air temperature leaving the preheater averages between 400 and 500 deg. F. depending somewhat on the operating conditions and fuel burning equipment.

Furnace construction continues to show increased use of water-cooled walls, especially in furnaces burning gas and oil. In some cases as much as 40 to 65 per cent of the heat absorbed by the boiler is being absorbed by the water walls. The average amount of water wall surface used seems to be about 6 to 8 per cent of the combined heating surface (boiler surface plus water wall plus integral economizer if any) but in the case of some of the larger high pressure boilers, this percentage goes up to 12 to 15 and in the case of Atwater Kent plant is about 36 per cent.

Ratios of cubic feet of furnace volume to square feet

FURNACES												
STATION	FUEL & METHOD OF FIRING	HEATING SURFACE SQ. FT. EACH	FURNACE VOLUME CU. FT. EACH	RATIO FURNACE VOLUME TO HTG. SURF.	MAXIMUM B.T.U. LIBERATED PER CU. FT. PER HR.	CORRESPONDING OUTPUT IN M. LB. STM. PER HR.	ARE ECONOM'Z'S USED ?	ARE A. PRE HTR USED ?	WATERWALL SURFACE: SQ. FT. PER BOILER	WATERWALL SURFACE: PERCENT OF TOTAL HTG. SURFACE	WATERWALL SURFACE: TYPE	FURNACE BOTTOM TYPE
JAMES H. REED	PENNA.-BIT STOKERS	35,025	16,670	0.475	34 300	———	YES	NO	3230	5·5	PLAIN TUBES & C.I. BLOCKS	———
BELLE ISLE	NATURAL GAS FORCED DRAFT BURNERS	13,318	6,700	0.50	31 000	150 000	NO	YES	648	4.9	BARE TUBES	AIR COOLED HOLLOW TILE
RIO GRANDE	GAS & OIL	16,502	9,200	0.56	38 000	184 500	NO	YES	1249	7.6	PROTECTED WATER TUBES	DRY
SHUFFLETON	OIL	26,591	18,230	0.69	27 000	330 000	NO	YES	1725	6·5	PROTECTED WATER TUBES	DRY
LOUISIANA	REFINERY # RESIDUALS	15,704	16,800	1.07	23 000	350 000	YES	YES	1887	12.0	PROTECTED WATER TUBES	SLAG TAP
ATKINSON	PULVERIZED COAL	30,200	25,120	0.83	22 500	450 000	NO	YES	3580	12·0	FIN TUBES	AIR COOLED HOPPER AND HEARTH SCREEN
GREAT WESTERN	GAS & OIL	22,250	17,025	0.76	17,000 PER CU.FT. COMB. CHAMBER	290 000	NO	NO	——	——	AIR COOLED 2000 SQ.FT.	AIR COOLED
DEEPWATER	OIL & NATURAL GAS	23,071	14,000	0.61	33,800	350,000	YES	YES	1473	6.7	TUBES WITH REFRACTORY WALLS	HOLLOW TILE AIR COOLED
DALLAS	GAS OIL AS AUXILIARY	14 780	5603	0·38	59905	250000	NO	YES	571	3.9	PROTECTED WATER TUBES	AIR COOLED
DEVILS RIVER	GAS	8650	8400	0.97	16 000	100 000	NO	YES	——	——	———	———
CONCEPCION ROAD	GAS & OIL	6001	7018	1·2	39 474	215 000	YES	YES	1011	16.8	PLAIN TUBES WITH REF-FACED C.I. BLOCKS	18" FIRE CLAY REF BRICK COVERED
SOUTH AMBOY	PULVERIZED COAL	13 673	12 900	0.95	26 500	275 000	YES	YES	2036	15	PROTECTED TUBES	SLAG TAP
WALDORF	PULVERIZED COAL	14 845	11 700	0.87	20 250	180 000	YES	YES	1385	11.0	BARE TUBES	WATER COOLED HOPPER
ATWATER KENT	PULVERIZED COAL	11 327	5 750	0·51	18 500	82 000	NO	YES	4124	36.4	BARE TUBES	WATER COOLED HOPPER
PROCTER & GAMBLE	WEST VIRGINIA STOKERS	5 729	2 320	0.405	34 000	60 000	NO	YES	198	3.5	C.I. BLOCKS	———
AMERICAN ENKA	BITUMINOUS U-F. STOKERS	5066	1400	0.28	50 000	45 000	NO	NO	——	——	———	ASH HOPPER
CALUMET & ARIZONA	CAL-FUEL OIL 18 500 B.T.U.	7253	2800	0·386	32 700	53 500	NO	NO	——	——	———	REFRACTORY AIR COOLED
WILLIAM WILHEIM	NO. 2 OR 3 BUCK-C-G. STOKERS	5920	725	0·137	———	53 280	NO	NO	——	——	———	———
PT. BREEZE	BITUMINOUS R.O.M. 13 500 B.T.U.	1-13 411 2-7 327	6660 3915	0·497 0·534	36 900 35 000	180 000 100 000	NO NO	NO NO	381-5 229-0	2·7 3·1	PLAIN TUBES WITH CJ.BLKS.	
BUREAU OF STANDARDS	W. VA. SLACK PULV 13000	2-5 088 2-3400	3500 2435	0·70 0·715	11 800	30 000 20 000	NO	* YES	2-88	1·72	CAST ON BLOCKS	FLAT BOTTOM
PROXIMITY	RAVEN RED ASH PULVERIZED	13338	15028	1·12	15 028	240 000	NO	YES	3,336	25.0	FIN TUBES	HEARTH SCREEN
UNIVERSITY OF NEBRASKA	COAL U.F. STOKERS	8100	2125	0·26	———	———	NO	NO	——	——	———	HOPPER
AMERICAN SALPA	PA & MD. R.O.M STOKER	5560	1100	0.2	57 200	45 000	NO	YES	310	5·5	PLAIN TUBES C.I. BLOCKS	WATER COOLED HOPPER
CHAMPION COATED PAPER	ISLAND CREEK 13 800 PULVERIZED	34 812	1900	0·54	23 000	393 000	NO	YES	2620	7.5	TUBES WITH C.I. BLOCKS	WATER COOLED HOPPER
TITANIUM PIGMENT	COAL STOKERS	4000	———	———	———	———	NO	YES	——	——	———	———

*NATURAL GAS, PULVERIZED CRUDE STILL COKE, PULV. CRACKING COIL COKE, FUEL OIL, LUBRICATING SLUDGE, ACID TAR, WAX TAILINGS, SODA BOTTOMS, NEUTRALIZED SLUDGE

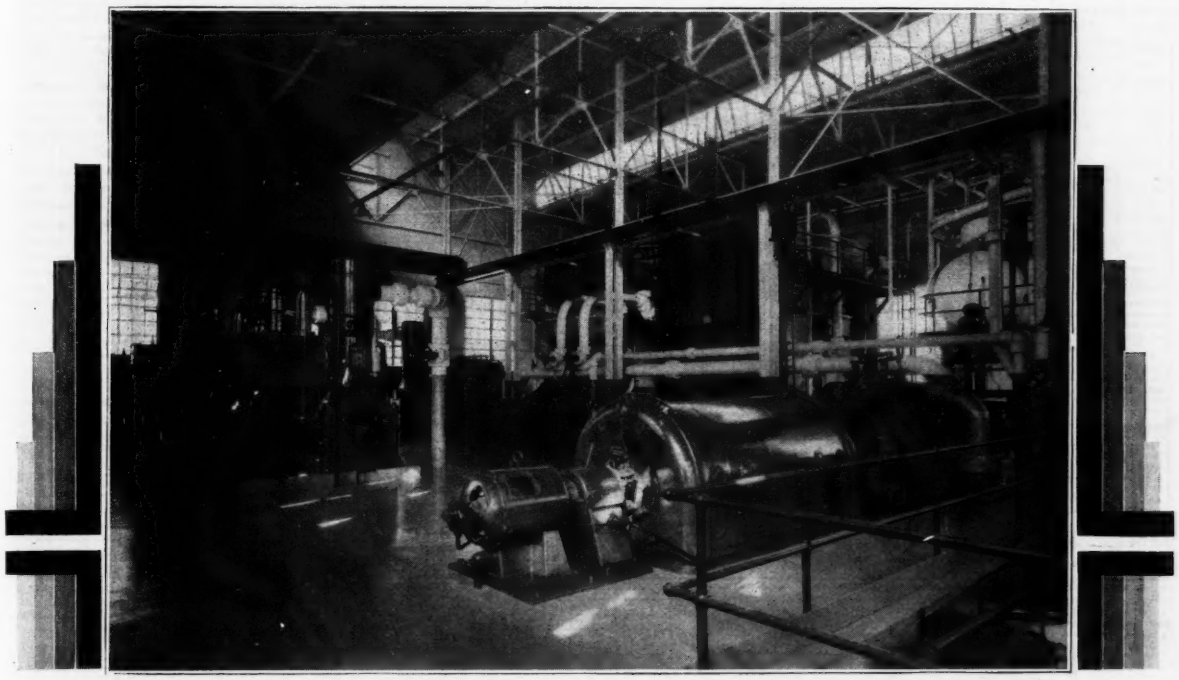
COMBUSTION EQUIPMENT

STATION	HEATING SURFACE SQ. FT. EACH	BLR. DRUM PRESSURE LB. PER SQ.IN. ABSOLUTE	FURNACE VOLUME CU.FT. EACH	FUEL KIND AND B.T.U.	% MOISTURE INITIAL	PULVERIZING MILLS					BURNERS		AIR SUPPLY						STOKERS									STOKER AIR SUPPLY			
						TYPE	NO PER BLR.	CAP TON PER HR. EA.	DRIVE AND POWER CONSUMED KW. HR/TON	MAXIMUM & MINIMUM FINENESS % THROUGH 200 MESH	TYPE	NO. PER BLR.	PRIMARY % TOTAL	PRIMARY WHERE INTRODUCED	PRIMARY TEMP. DEG. F.	SECONDARY % TOTAL	SECONDARY WHERE INTRODUCED	SECONDARY TEMP. DEG. F.	TYPE	LB. COAL PER SQ. FT. PER HR. MAX.	RATIO OF BLR. HTG. SURFACE TO SQ. FT. GRATE	PROJECTED GRATE AREA SQ FT	DRIVE	NUMBER RETORTS UNDER FEED	NUMBER TUYERES UNDER FEED	CHAIN GRATE LENGTH-L WIDTH-W IN FEET	ZONE CONTROL IF SO-NO. ZONES	AIR FOR COMBUSTION PRESSURE INCHES H2O	AIR FOR COMBUSTION TEMP °F	AIR FOR COMBUSTION CORRESPONDING OUT PUT PER BLR.
JAMES H REED	35 025	463	16 870	PA+BITUMIN-13,000	3.0														UNDER FEED	70	50-5	626-5	HYDRAULIC	18	45 INCL-OVERFEED SECTION		2	6-0	70	350 000
BELLE ISLE	13 318	430	6 700	OKLA. NAT. GAS 1050 B.T.U. PER CU. FT. AT ATM. PRESSURE	—						COMB. OIL&GAS FORCED DRAFT TYPE. WIDE RANGE	10				100	BURNER	510												
RIO GRANDE	16 502	465	9 800	GAS 980 OIL 18 500	1.0						COMBINATION GAS & OIL	10																		
SHUFFLETON	26 561	486	18 230	OIL 18 500 FUTURE HOGGED FUEL	UNDER 1-0						MECHANIC-ATOMIZATION	18																		
LOUISIANA	15 704	685	16 800	RESIDUALS SEE FUEL HAND-TABLE	GAS - 0.0 COKE 2-10 OIL UNDER 10 SURGE 30-35	AIR SWEPT BALL MILL	1	2-3/4	MOTOR DRIVEN MILL 19 EXHR. 3-5	MIN. 90 %	COMB. GAS & OIL & TURB. P.C. BURNER	18	10	MILL	400	90	BURNER	400												
ATKINSON	30 200	473	23 120	KY. OR ALA. 13,000	3-5	IMPACT	4	6	MOTOR 33-3		FORCED DRAFT	6		MILL	150		BURNER	450												
GREAT WESTERN	22 250	485	17 025	CAL. NAT. GAS 1100	—						COMB. OIL & GAS WIDE RANGE	20 MAIN 9 PILOT	100	BURNER	175															
DEEPWATER	23 071	1480	14 880	NAT-GAS 1000 OIL 18,000	—						COMBINATION OIL & GAS	20																		
DALLAS	14 780	385	5803	NAT. GAS OIL	—																										
DEVILS RIVER	8650	400	8400	NAT GAS 1135 PER CU.FT.	—						COMB. OIL & GAS	7	100	THROUGH AIR COOLED WALL TO BURNER	400															
CONCEPCION ROAD	8001	1485	7018	GAS 980-1000 OIL — 18,975	—						COMBINATION OIL & GAS	10	100	BURNER	342															
SOUTH AMBOY	13 873	1400	12900	COAL	—	AIR SWEPT BALL MILLS	5	2-1/2	VAR. SPEED A.C. MOTOR	80 % MAX.	TURBULENT FCD. DRAFT	5	15	MILL ENTRY MILL EXIT	325	70	BURNER	465												
WALDORF	14 845	985	11 700	BIT. SCREENING 13 300	4	IMPACT	2	6	MOTOR 18 AT MAX-CAP.	65 % MIN.	TURBULENT	2	100	MILL	340															
ATWATER KENT	11 327	215	5 750	PA 14 000	LESS THAN 3	IMPACT	1	4-1-4	75 HP MOTOR 8 — FULL LOAD	80	TURBULENT	1	20	MILL	350	80	BURNER	350												
PROCTER & GAMBLE	5 729	485	2320	W.VA. 13,300	1-0														UNDER FEED	48-0	42-4	130-6	4 SPEED MOTOR	5	29			3	350	60 000
AMERICAN ENKA	5066	365	1400	VA. 13 500	—														UNDER FEED	55	49	103	4 SPEED MOTOR	5			3	5		30 000
CALUMET & ARIZONA	7253	412	2 600	CAL-FUEL OIL 18 500	—						MECHANICAL ATOMIZATION	3																		
WILLIAM WILHEIM	920	190	725	BUCKWHEAT 11,300	3-28														CHAIN GRATE	40.4	36.77	181	VERTICAL STM. ENGINE			L-15'-0" W-11'-0"	6	5	70	53 280
PT BREEZE	13 411 7 327	462	6880 3915	BITUMINOUS 13 500	3-4														UNDER FEED	58-5 57-0	40-2 39-9	320.7 178-0	VAR. SPEED A.C MOTORS	11 6	37 37		4 4	5-0 5-0	150 150	180 000 100 000
BUREAU OF STANDARDS	2-5088 2-3400	215	3 500 2 435	W VA. 13 000	6	IMPACT	1	2-3500 # 2-2000 #	IND. MOTOR	60	HORIZONTAL TURB.	1	90	MILL	350	10	BURNER	ROOM												
PROXIMITY	13 388	465	15 028	RAVEN RED ASH 13 800	1-5	IMPACT	2	2-75	MOTOR 8	70 MAX 55 MIN.	HORIZONTAL TURB.	2	18	MILL	400	82	BURNER	430												
UNIVERSITY OF NEBRASKA	6100	285	2125	COAL 10 500 TO 11 200	3-5														UNDER FEED	49.4	49.8	162.6	TURBINE	10	25		2	10.0	ATM.	
AMERICAN SALPA	5560	415	1100	PA & MD. 14 000	6.0														UNDER FEED	45	56.0	98.2	VAR. SPEED MOTOR	4	33		3	ATM.		
CHAMPION COATED PAPER	34812	669	1900	ISLAND CREEK 13 800	2-5	IMPACT	4	5	20	70-75	HOR TURB	2	15	WITH COAL 15 FT ABOVE MILL	550	85	BURNER	550												
TITANIUM PIGMENT	4000	280	—	COAL	—														CHAIN GRATE				VERT. STEAM ENGINE			L-15'-2" W-8'-5"	3			

of heating surface do not show much change from last year. If anything the use of water-cooled walls tends to lower this ratio as a higher heat liberation can be obtained due partly to the absorption of the walls and partly to the use of turbulent burners producing shorter flames.

The heat liberation figures as shown in the table are higher on the whole than in previous years. Values of well over 25,000 B.t.u. per cu. ft. per hour are common. Dallas station, burning gas, has a maximum heat liberation of 59,905 B.t.u., American Salpa with underfeed stokers a value of 57,000, American Enka with underfeed stokers, 50,000 and so on.

Several slag tap furnaces are noted on the tables such as those at Louisiana and South Amboy, while the standard water-cooled hopper bottom is often used with some of the pulverized coal furnaces. At the Dallas plant, burning natural gas with fuel oil as auxiliary, the furnace at present has a flat air-cooled bottom but the water-cooled side walls are designed so that if it is desired to use pulverized fuel in the future, a water-cooled hopper bottom can be easily installed. Furnaces at Shuffleton are designed for burning oil at present but provision is made for burning hogged fuel in the future. Air-cooled furnace bottoms with water-cooled side walls predominate in the station burning gas and oil.



VIEW IN THE COMBINED BOILER AND TURBINE ROOM OF THE CALUMET & ARIZONA PLANT

Types of Fuels

Wide variation in type of fuel burned is shown by the table. All grades of coal are burned either on stokers or in pulverized form, natural gas and oil form the fuel for many southern or western plants, while one plant, Louisiana, was designed to burn all the available refinery residuals from the refinery to which it supplies steam and power.

Initial moisture in coal seems to average 3 to 5 per cent in the plants tabulated. If this coal is burned as pulverized fuel, all the drying necessary is done in the pulverizing mill, as the separate coal dryer has not been installed in any of these plants and there seems to be a trend to abandon it in favor of mill drying even with central pulverizing systems.

Coal Pulverizing Equipment

The table for pulverizing equipment illustrates the present trend toward the use of direct firing or the unit mill system of pulverized coal. It is true that, of the total amount of pulverized fuel used, more boiler horsepower is installed with central systems than with unit system but the rate of installation of unit systems is increasing much faster than that of central systems and there seems to be a most decided trend toward the unit system.

Attempt was made to collect data on power consumption per ton of coal pulverized and a maximum and minimum of fineness. The few figures reported do not permit of much generalization. The minimum fineness through 200 mesh is often the point at which pulverizing mill hammers are usually replaced and this probably lies in the neighborhood of 50 to 65 per cent through 200 mesh while the maximum fineness seems to be between 70 and 80 per cent through 200 mesh although at South Amboy 90 per cent through 200 mesh is called for.

Turbulent Burners and Air Supply

There appears to be a definite trend toward the use of turbulent burners for pulverized coal, while most of the stations burning gas and oil use a combination wide range type of burner.

Some pulverized coal plants introduce 10 to 20 per cent combustion air at the pulverizing mills at temperatures as high as 400 deg. F.; the remainder of the combustion air from 90 to 80 per cent is usually introduced at the burners at about the same temperature.

STATION	COMBINED HEATING SURFACE SQ.FT. PER UNIT	BOILER PRESS. ABS.	SUPERHEATERS TYPE	SUPERHEATERS HEATING SURFACE PER BLR. SQ.FT.	SUPERHEATERS HEATING SURFACE PER BLR. % B.H.S.	SUPERHEATERS ELEMENTS DIA. IN.	SUPERHEATERS ELEMENTS B.W.G. NO.	SUPERHEATERS TEMP. TOTAL DEG. F.	SUPERHEATERS CORRESPONDING BOILER OUTPUT	ECONOMIZERS TYPE	ECONOMIZERS HEATING SURFACE SQ.FT.	ECONOMIZERS HEATING SURFACE % C.H.S. *	ECONOMIZERS LOCATION	ECONOMIZERS TEMPERATURE WATER IN	ECONOMIZERS TEMPERATURE WATER OUT	ECONOMIZERS TEMP. GAS IN	ECONOMIZERS TEMP. GAS OUT	AIR PREHEATERS TYPE OF AIR PREHEATER	AIR PREHEATERS NO. PER BOILER	AIR PREHEATERS HEATING SURFACE SQ.FT. EACH	AIR PREHEATERS CAPACITY LB. AIR PER HR. TOTAL	AIR PREHEATERS AIR TEMPERATURE IN	AIR PREHEATERS AIR TEMPERATURE OUT	AIR PREHEATERS GAS TEMP. IN	AIR PREHEATERS GAS TEMP. OUT
JAMES H REED	31 795	415	CONVECT	9444	29.7	2	——	735	350 000	WATER	13 572	16.2	BEHIND BOILERS	288	393	775	489	——	——	——	——	——	——	——	——
BELLE ISLE	13 318	400	RADIANT	606	4.6	2	7	750	150 000	——	——	——	——	——	——	——	——	ROTARY ELEMENT	1	22 000	178 000	80	510	735	362
RIO GRANDE	21 827	465	INVERTED CONVECT.	4785	31.4	2	9	750	184 500	——	——	——	——	——	——	——	——	VERTICAL TUBULAR	1	19 450	223 000	110	500	840	455
SHUFFLETON	33 071	465	INVERTED CONVECT.	6480	28.1	2	9	730	330 000	——	——	——	——	——	——	——	——	PLATE	1	18 360	366 800	80	430	890	605
LOUISIANA	23 389	685	INVERTED CONVECT.	7685	55.6	2	8	750	350 000	WATER	9801	41.9	BEHIND BOILER	350	438	960	638	PLATE	1	32 800	345 500	100	438	638	360
ATKINSON	36,370 40 600	490	▲ CONVECT.	4590 6820	15.2 22.6	1 1/2 ——	9 ——	753	400 000	——	——	——	——	——	——	——	——	ROTARY ELEMENT	1	30 000	521 300	100	575	770	435
GREAT WESTERN	22 250	465	CONVECT.	9280	41.5	2	8	625	290 000	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——
DEEPWATER	23 071	1380	CONVECT.	8200	36.0	2	——	†† 830	350000	STEAMING	13 820	60.0	BEHIND BOILER	350	539	1370	723	VERTICAL TUBULAR	1	31 154	357 000	80	479	723	405
DALLAS	14 780	385	INTERDECK CONVECT	2850	20.1	2	10	750	250000	——	——	——	——	——	——	——	——	REGENERATIVE	2	27 000	328 500	100	526	864	276
DEVILS RIVER	8 650	400	CONVECT	——	——	1 5/8	10	725	85 000	——	——	——	——	——	——	——	——	PLATE	1	10 450	81100	195	435	625	400
CONCEPCION ROAD	17 881	1485	CONVECT	4640	92.9	2	1/4"	810	196 000	INTEGRAL STEAMING	11 880	66.5	BEHIND BOILER	375	541	1200	582	PLATE	1	13 900	191 500	80	343	582	
SOUTH AMBOY	13 673	1400	CONVECT	12900	95.0	——	——	●● 750	275000	STEAMING	4423	32.0	BEHIND BOILER	520	545	——	——	TUBULAR	1	32 052	——	80	477	635	317
WALDORF	14 845	665	CONVECT	——	——	——	——	730	150 000	■ INTEGRAL	——	——	——	250	——	——	——	TUBULAR	1	15 200	15 200	90	340	——	350
ATWATER KENT	11 327	215	CONVECT.	950	8.5	——	——	488	——	——	——	——	——	——	——	——	——	TUBULAR		11 250	91 500	70	410	650	320
PROCTER & GAMBLE	5729	465	INVERTED CONVECT	710	12.8	2	10	750	48 000	——	——	——	——	——	——	——	——	TUBULAR	1	3534	54 000	80	328	685	475
AMERICAN ENKA	5066	365	CONVECT.	2500	50	2	——	710	30000	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——
CALUMET & ARIZONA	7255	412	CONVECT. 4 LOOP	1227	16.9	1 5/8	10	850	53 500	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——
WILLIAM WILHEIM	——	——	——	——	——	——	——	——	——	— NONE	INSTALLED	——	——	——	——	——	——	——	——	——	——	——	——	——	——
PT BREEZE	——	——	——	——	——	——	——	——	——	— NONE	INSTALLED	——	——	——	——	——	——	——	——	——	——	——	——	——	——
BUREAU OF STANDARDS	5088 3400	215	CONVECT.	200 430	3.78 8.9	2	10	487	——	——	——	——	——	——	——	——	——	——	PREHTD	AIR FROM	WALLS ONLY	——	——	——	——
PROXIMITY	13388	465	CONVECT.	6600	41.0	1	8	645	90000	——	——	——	——	——	——	——	——	PLATE		——	——	85	420	580	400
UNIV OF NEBRASKA	8100	265	CONVECT.	——	——	——	——	556	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——
AMERICAN SALPA	5560	415	CONVECT.	——	——	——	——	——	——	INTEGRAL	1250	22	——	——	——	——	——	——	——	——	——	——	——	——	——
CHAMPION COATED PAPER	34 812	670	CONVECT.	5300	19.5	——	——	750	343000	——	——	——	——	——	——	——	——	TUBULAR	1	47 742	——	——	550	——	——
TITANIUM PIGMENT	4000	290	CONVECT.	——	——	——	——	——	——	——	——	——	——	——	——	——	——	ROTARY ELEMENT	1	——	——	——	325	——	——

SUPERHEATER, ECONOMIZER, AIR PREHEATER

* C.H.S. = BOILER SURFACE + W. WALL SURF. + INTEGRAL ECON SURF. IF ANY

†† THIS & ALL FOLLOWING DATA APPLY AT 350,000 LB PER HR USING NATURAL GAS & 10% EXCESS AIR

▲ TWO DIFFERENT MAKES.

●● TEMP. HELD TO THIS VALVE AUTOMATICALLY BY SUBMERGED TYPE DESUPERHEATER.

■ HEATER SECTION OF BOILER SURFACE INCLUDED IN BOILER SURFACE FIGURE.

Champion Coated Paper Co. uses air temperatures at both mill and burner of 550 deg., the air to the mill being introduced with the coal 15 ft. above the mill. South Amboy introduces 15 per cent of the preheated carrying air at the mill entrance at 325 deg. 15 per cent at the mill exit where the velocity is increased and the remaining 70 per cent at the burner at 465 deg. At the Waldorf plant all the air at 340 deg. is passed through the mills while at the Bureau of Standards plant 90 per cent of the air at 350 deg. goes through the mill, the remainder, at room temperature being added at the burner.

Only two of the plants tabulated use one burner per furnace; the others use two or more. Furnaces burning gas and oil employ from 10 to 20 burners per furnace.

STATION	COMBINED HEATING SURFACE PER UNIT	BOILER PRESS. ABS.	RESUPERHEATERS CAPACITY LB. PER HR. MAX.	STEAM SECTION SURFACE SQ.FT.	STEAM SECTION STM. TEMP. IN	STEAM SECTION STM. TEMP. OUT	GAS SECTION SURFACE SQ.FT.	GAS SECTION STM. TEMP. IN	GAS SECTION STM. TEMP. OUT	GAS SECTION GAS TEMP. IN	GAS SECTION GAS TEMP. OUT	CORRESPONDING BOILER OUTPUT LB. PER HOUR
DEEPWATER	23 071	1380	1 THOROFARE 1 DEADEND	H.P. STEAM SECTION 4300 4300	820 715	715 577	L.P. STEAM SECTION	563 460	710 583	—	—	643,000 FROM 2 BOILERS
CONCEPCION ROAD	17 881	1485	196 000	2080	445	545	——	—	—	—	—	196 000
SOUTH AMBOY	13 673	1400	COMBINED 226 000	12900	520	—	13000	—	750	1200	—	250 000

At South Amboy, five pulverizing mills serve each boiler, each mill supplying its own burner, to secure accurate control of the flame at all loads. By means of a special manually operated combustion control system, the preheated air to mills and burners and the coal to the mills are premeasured, to insure accuracy of control and proper air-to-coal ratios over the entire range of load.

Stoker Practice

Of the underfeed stokers tabulated those at James H. Reed station are designed to burn 70 lb. of coal per sq. ft. of grate surface per hour maximum, without preheated air. Others are designed to burn 45 to 55 lb. per sq. ft. per hour, in some cases with preheated air as at Procter & Gamble, using air at 350 deg., or Point Breeze, using air at 150 deg., or University of Nebraska and American Salpa, with air at room temperature.

Draft used with these stokers seems to average about 5 in. H_2O and in almost all cases, with both chain grate and underfeed stokers, arrangements are made to control the air going to various parts of the fuel bed, to secure best combustion conditions over the whole length of the stoker.

BOILER DATA

STATION	NO.	TYPE	CAPACITY PER BOILER LB. PER HR. NORMAL	CAPACITY PER BOILER LB. PER HR. MAX.	ABSOLUTE PRESSURE LB. PER SQ. IN.	HEATING SURFACE PER BOILER: BOILER SQ. FT. B.H.S.	WATER WALLS SQ. FT.	WATER WALLS % C.H.S.	SUPERHEATER SQ. FT.	SUPERHEATER % C.H.S.	RESUPERHTR. STEAM OR GAS	RESUPERHTR. SQ. FT.	ECONOMIZER SQ. FT.	ECONOMIZER % C.H.S.	A.PREHTER SQ. FT.	NO. PASSES	FURNACE VOL. CU. FT.	FURNACE VOL. CU.FT. PER SQ.FT. C.H.S.	TUBE BANK WIDE	TUBE BANK HIGH	DRUMS NO.	DRUMS TYPE	DRUMS STEAM DIA.	DRUMS STEAM LENGTH
JAMES H. REED	3	VERT. BENT TUBE	250 000	350 000	415	31 795	3230	5·5	9,444	16.2	——	——	13 572	23·3	——	3	16 670	0·287	64	——	4	FORGE WELDED	UPPER 41 5/8 ID	REAR 40'-3"
BELLE ISLE	3	HOR. CROSS DRUM	150000	180 000	400	12 670	648	4·9	806	4·6	——	——	——	—	22 000	3	8 700	0.50	40	18	1	FORGE WELDED	54"	27'-0"
RIO GRANDE	2	VERT. BENT TUBE	——	184 500 CONT.	465	15 253	1249	7.8	4 785	29.0	——	——	——	——	19 450	4	9 200	0·56	38	20	3 1	RIVETED STEAM MUD	36" 48" 42"	31'-5" 28'-1" 27'-9"
SHUFFLETON	3	VERT. BENT TUBE	——	330 000 CONT.	485	15 253	1249	7·6	4785	29.0	——	——	——	——	18360	3	18 230	0.89	55	20	3 1	RIVETED STEAM MUD	36" 48" 48"	36'-0" 34'-1" 34'-1"
LOUISIANA	4	HOR. CROSS DRUM	——	350 000 CONT.	685	13 817	1887	12	7685	49.0	——	——	9801	62	32800	3	16 800	1.07	40	12	1	RIVETED	60"	35'-9"
ATKINSON	2	HOR CROSS DRUM	400 000	450 000	440	30 200	3580	9.3	4590 6 820	12·0 16·8	——	——	——	—	30000	3	25 120	0·83	51	20	1	RIVETED	72"	36'-8"
GREAT WESTERN	2	HOR. CROSS DRUM	290000	290000	465	22 250	——	——	9280	41·5	——	——	——	—	——	3	17025	0·78	56	13	2	RIVETED MAIN AUX.	72" 36"	39'-8" 30'-0"
DEEPWATER	2	HOR. STRAIT TUBE CROSS DRUM	——	380000	1450	7778	1473	6·4	8200	36	2 THOR-OFARE 2 DEAD END	8600 TOTAL 8600 TOTAL	13820	60	31154	1	14000	0.61	44	8	1	SOLID STEEL FORGING	52"	43'-0"
DALLAS	1	CROSS DRUM	175000	250000	385	14 209	571	3·9	2850	19.3	——	——	——	——	2 PREHTRS. 27,000 SQ. FT EACH	3	5603	0·38	36	18	1	——	54"	28'-8"
DEVILS RIVER	3	BENT TUBE	75000	100 000	400	8650	——	——	——	——	——	——	——	——	10 450	1	8400	0.96	28	18	4	RIVETED	36" 42" 48" 48"	21'-8 1/2" 21'-7 1/2" 22'-1" 17'-8"
CONCEPCION ROAD	1	HOR. CROSS DRUM	153000	215 000	1464	4990	1011	568	4640	26·0	STEAM	2060	11880	666	13900	1	7018	0·39	27	8	1	FORGED	51·5"	31'-8"
SOUTH AMBOY	3	HOR. CROSS DRUM	250000	275000	1400	7214	2036	15.0	12 900	95·0	STEAM GAS	12,900 13,000	4423	32·0	32 052	1	12900	0·94	40	8	1	FORGED	——	——
WALDORF	2	CROSS DRUM SINGLE PASS	150 000	180000	665	13 480	1385	9.3	——	——	——	——	HEATER SECT. OF BOILER		15200	1	11 700	0.87	35	——	9	RIVETED	48"	28'-0"
ATWATER KENT	3	V. TYPE 4 DRUM	45 000 60,000	85000	215	7203	4124	36.4	950	8·4	——	——	——	——	11 250	3	5750	0·51	——	——	4	RIVETED	——	——
PROCTER & GAMBLE	3	VERT. BENT TUBE	46000	60 000	465	5531	198	3·5	710	12·8	——	——	——	——	3534	4	2320	0.403	18	——	4	RIVETED	2-42" 1-36"	10'-9 1/2"
AMERICAN ENKA	4	HOR. CROSS DRUM	30000	45000	365	5066	——	——	2500	50	——	——	——	——	——	—	1400	0.28	10	14	—	RIVETED	——	——
CALUMET & ARIZONA	2	HOR. CROSS DRUM	36100	53500	412	7253	——	——	1227	16·9	——	——	——	——	——	3	2800	0·39	21	18	1	RIVETED	54"	17'-11"
WILLIAM WILHEIM	2	HOR. CROSS DRUM	17760	53280	190	5290	——	——	——	—	——	——	——	——	——	3	725	0.137	37	9	1	RIVETED	54"	11'-6"
PT BREEZE	3	3 DRUM INCLINED	1-180 000 2-100000	200000 110000	462 462	13 050 7098	361·5 229	2·7 3·1	— —	— —	— —	— —	— —	— —	— —	3 3	6600 3915	0·511 0·552	38 25	15 15	3 3	RIVETED	48" 48"	22'-11" 16'-2"
BUREAU OF STANDARDS	2	3 DRUM BENT TUBE HOR. LONG-DRUM	15000 10200	30000 20400	215	5000 3400	88 —	1·72 —	200 430	3·78 8·9	— —	— —	— —	— —	FURNACE WALLS ONLY	3	3500 2435	0.70 0.71	12	14	3 2	RIVETED	48" 48-54" 36"	12'-0" 11'-0" 20'-0"
PROXIMITY	2	BENT TUBE	50 000	120 000	465	10000	3338	25	6600	41·0	——	——	——	——	——	1	15 028	1·12	——	——	4	RIVETED	42"	36'-0"
UNIVERSITY OF NEBRASKA	4	ST. TUBE 4 DRUM	28 000	70000	265	8100	——	——	——	——	——	——	——	——	——	—	2125	0.28	27	17	3	RIVETED	42"	22'-0"
AMERICAN SALPA	2	BENT TUBE	12 000	38000	415	4000	310	5·5	——	——	——	——	1250	22	——	2	1100	0.2	——	——	4	RIVETED	48" 36" 36" 30"	11'-0"
CHAMPION COATED PAPER	1	HOR CROSS DRUM		343000	670	27192	2620	7.5	5300	15.2	——	——	——	—	47742	2	19080	0·54	45	22	1		54"	36'-1"
TITANIUM PIGMENT	3	HOR. CROSS DRUM	——	——	290	4000	——	——	——	——	——	——	——	——	——	2	——	—	——	——	1	——	——	——

*C.H.S. = BOILER SURF. + W. WALL SURF.+ INTEGRAL ECON. SURFACE. IF ANY.

Use of water-cooled furnace walls with stokers is increasing and there have been improvements in refractory wall designs, both in methods of supporting and in types of refractories for varying conditions.

Welding to Become a Factor in Boiler Development

Methods of welding have progressed so rapidly that many engineers prophesy the acceptance of welding for pressure parts of the steam generating units in the near future. One of the most significant events of the year was the public announcement by two large and influential manufacturers of the development of fusion welding technique suitable for boiler drum construction. This strengthened by the action of the Navy, which unhampered by boiler code requirements, has ordered both welded, superheater headers and welded boiler drums, indicates that the proposed specifications being considered by the boiler code committee will be acted upon favorably with only minor changes.

Maintenance of proper sulphate or phosphate carbonate ratio of boiler feedwater is generally agreed to prevent embrittlement, while forged or welded boiler drums are also advocated as aids in preventing it. Several of the stations tabulated, use forged drums with pressures varying from 400 to 1400 lb.

Feedwater Investigations Indicate Changes

CHANGES IN FUTURE FEEDWATER TREATMENT INDICATED BY RECENT INVESTIGATIONS. EFFECT OF VARIOUS INFLUENCES. PRESENT PRACTICES SUMMARIZED

GROWING USE of high-pressure steam and increasing employment of high ratings raise considerably the importance of proper boiler water treatment and have led to a considerable amount of intensive research during the past few years, especially during the last year. Notable among those who have contributed recently to advance thought on feedwater treatment are Messrs. Hall, Parr, Straub and Partridge.

EMBRITTLEMENT INHIBITION

Hall,[1] in discussing embrittlement inhibition, cites the more recent work of a number of investigators and indicates that destructive effect on boiler tubes and plates is due to a combination of forces. He presents a diagram showing regions of acid attack and caustic attack and between them a region of protection which reduces as operating pressure (temperature) increases. The dual character of caustic, namely, protective until corrosive concentration dependent on temperature is reached whereupon it begins its selective attack and development of hydrogen, is shown.

Dominating effect of cyclic stresses in causing rapid deterioration, showing that the higher the stress the more rapid the corrosion and deterioration, is clearly indicated. Simultaneous combination of corrosion and cyclic stress is shown as cause of failure in metals where either factor of itself would not have achieved this result.

Inside calking of seams as a positive protective means against caustic attack at this point is brought out by the Southern California Edison Co. It is found, however, that if inside calking is not properly done attack may even be accelerated. Influence of corrosion accelerators and inhibitors on embrittlement is discussed by Speller. It is shown that protective coatings are broken by cyclic stresses and that this action occurs equally with slow as well as fast repetitions of stress. Parr & Straub[2] have demonstrated the attractive possibilities of the phosphates for forming protective films against caustic attack and chromates and arsenates are offered as possibilities in this connection.

In summarizing the preventive methods in practice, Hall[1] states that the key to satisfactory conditions in the boiler water lies in the maintenance of the necessary, but no more than necessary causticity. With the establishment of low causticity, maintenance of the recommended sulplate—alkaline ratios presents little, if any, difficulty.

Clean evaporative surfaces simultaneous with low causticity are maintained with greatest certainty, it is stated, by definite phosphate control of the boiler water, the phosphate serving as a secondary line of defense to the sulphate in protection of the metal at the seams. Control of causticity concentration is obtained readily by use of the phosphate conditioning chemical of appropriate alkaline-reducing capacity in the boiler water.

[1]N.E.L.A. Publication No. 051, June, 1930.
[2]Bul. 177, Eng'g. Exp. Sta., Univ. of Ill.

Straub,[1] in his discussion of the determination of the proper ratios to prevent embrittlement, points out other requirements than merely a definite ratio between the sodium phosphate and total alkalinity in boiler water tentatively recommended in the A.S.M.E. Boiler Code and shows that as the concentration of sodium hydroxide diminishes, the time rate of cracking rapidly increases. He also discusses sodium carbonate and sodium sulphate as inhibitants of embrittlement.

CHANGES IN SCALE PROPERTY CONCEPTS

Partridge[3] has made an intensive study of the formation and properties of boiler scale that will have an influence on future water treatment. Contrary to common impression, he states, porous scales are poorer conductors of heat than dense scales, due to the inclusion of steam in the interstices. A very slight deposit of a hard dense scale may, however, cause the overheating and failure of boiler tubes exposed to direct radiation. Although this overheating is the most serious effect of this scale its effect on overall boiler efficiency, he says, is much less than commonly quoted.

Prevention of scale, Partridge contends depends upon either extremely complete softening of feedwater or upon careful control of the chemical equilbra in the boiler water to precipitate as solid material, a substance which will form scale only with extreme slowness, if at all. For external softening, the hot process lime-soda, lime-barium and either lime-zeolite or zeolite-acid systems are most important at this present time. Internal conditioning with soda ash is limited to lower pressures because of the high alkalinity developed in the boiler water by hydrolysis of carbonate but phosphate conditioning is applicable at any pressure particularly when used in conjunction with some type of external softening treatment.

CLEAN BOILERS WITH HIGH CONCENTRATION

Tobey[4] found that higher concentration produced cleaner boilers. In one of his tests it required 6 hr. for suspended matter to settle appreciably into the lower drum after the fire had been completely removed from the stoker. In another, he found no general settling action toward the lower drum at any time during the 144-hr. test.

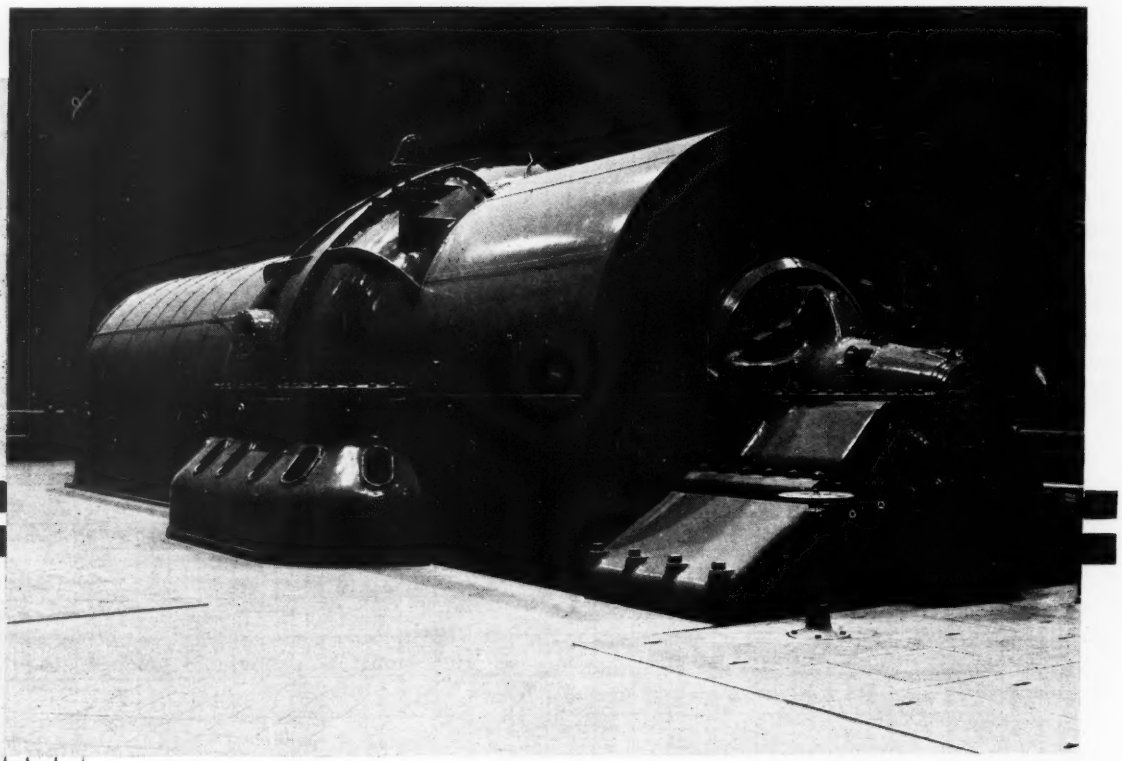
General use of evaporators, especially in large steam central stations operating under high ratings, is evidenced also. The steam pressure employed on evaporators covers a wide range. South Amboy takes its evaporating steam at the pressure of its first stage extraction point of the low-pressure turbine element, which is 8.2 lb. abs. while the Great Western Power Co. uses a pressure as high as 625 lb. Here a 15,000-gal. hot water storage tank acts as a thermal storage providing for the rapid changes of load which prevail at this plant.

[3]Eng'g Research Bul. No. 15, June, 1930, Univ. of Mich.
[4]Power Plant Eng'g., May 1, 1930, p. 491.

FEEDWATER TREATMENT AND HEATING

STATION	TREATMENT: SOURCE OF MAKE-UP	SYSTEM	IS WATER TO EVAP. TREATED?	EVAPORATORS: EFFECTS 1 OR 2	STEAM PRESS. TO EVAR LB.	LOCATION EVAP. AND COND.	CAPACITY LB. PER HOUR	HEATING: SOURCE	TYPE HEATER	FINAL FEED TEMP. DEG. F.	STAGE WATER HEATING TEMPERATURE DEG. F. — EJECTOR IN	EJECTOR OUT	OIL COOLER IN	OIL COOLER OUT	GEN. AIR COOLER IN	GEN. AIR COOLER OUT	DEAER. HEATER IN	DEAER. HEATER OUT	EVAP. IN	EVAP. OUT	EXTRACTION HEATERS NO. 1 IN	NO. 1 OUT	NO. 2 IN	NO. 2 OUT	NO. 3 IN	NO. 3 OUT	NO. 4 IN	NO. 4 OUT	NO. 5 IN	NO. 5 OUT	ECON. IN	ECON. OUT
JAMES H REED	RIVER	ZEOLITE	YES	2	158.6 ABS	MEZZANINE FLOOR IN TURBINE ROOM	7500	EXTRACTION	CLOSED	288	87	91	NOT HEAT	IN CYCLE	77	87	—	—	—	—	112	196	196	244	244	288	—	—	—	—	288	393
BELLE ISLE	LAKE OR DEEP WELL	ZEOLITE & EVAPORATOR	YES	1	85	MEZZANINE FLOOR IN TURBINE ROOM	10 200	EXTRACTION	CLOSED	375	101	105	103 NOT	108 IN HEAT CYCLE	95	103	—	—	232	260	105	160	176	232	260	300	300	375	—	—	—	—
RIO GRANDE	RIVER	EVAPORATION	NO	1	91	AUXILIARY BAY	10 000	EXTRACTION	CLOSED & DEAERATING	310	88	91	—	RAW WATER	—		166	215	215	220	215	317	168	214	91	167	—	—	—	—	—	—
SHUFFLETON	LAKE	EVAPORATION	NO	1	173	AUXILIARY BAY	13 720	EXTRACTION	CLOSED & DEAERATING	363	—	—	—	—	—	—	173	227	—	—	227	349	78	173	—	—	—	—	—	—	—	—
LOUISIANA	RIVER	COLD INTERMITTENT LIME & ZEOLITE	—	—	—	—	—	EXTRACTION	OPEN DEAERATING & CLOSED	353	—	—	83	86	86	90	122	232	—	—	222	353	84	116	—	—	—	—	—	—	353	438
ATKINSON	RIVER	FILTER AND EVAPORATION	YES	1	95 ABS	EVAP. ON TURBINE ROOM FLOOR	24000	EXTRACTION	CLOSED	386	101	104	FOR	NOT USED FEEDWATER HEATING			—	—	264	301	104	169	264	301	319	319	385		—	—	—	—
GREAT WESTERN	CITY MAIN	CHEMICAL	YES	1	625	BACK OF BOILERS	13 500	EXTRACTION	CLOSED & DEAERATING	261	75	95	—	—	—	—	164	210	—	—	210 EVAP.	261 COND	—	—	—	—	—	—	—	—	—	—
DEEPWATER	WELLS	EVAPORATION	NO	1	137	AUXILIARY BAY	12 000	EXTRACTION	CLOSED & DEAERATING	379	111	115	108	111	101	108	268	283	283	292	292	358	203	268	115	183	183	203	358	379	379	560
DALLAS	CITY MAIN	EVAPORATION	NO	1	150 ABS.	COND PIT	10000	EXTRACTION	CLOSED DEAERATING FOR EVAPS.	370	108	109	104	106	97	104	271	281	281	300	300	370	189	271	105	188	—	—	—	—	—	—
DEVILS RIVER	RIVER	LIME AND SODA EVAPORATION	YES	1	50	BASEMENT	3200	EXTRACTION	CLOSED & DIRECT CONTACT	330	98	110	138	118	—	—	214	235	160	214	110	160	235	330	—	—	—	—	—	—	—	—
CONCEPCION ROAD	ARTESIAN WELLS	INTERNAL PHOSPHATE & HYDROXIDE EVAP.	YES	—	USING	OLD BOILER	—	EXTRACTION	CLOSED & DEAERATING	378.1	101		135					315.1	—	—	111.1	187.2	—	—		378.1	—	—	—	—	375	541
SOUTH AMBOY	DEEP WELLS	EVAPORATOR	NO	1	8.2 ABS.	IN BOILER ROOM		EXTRACTION	OPEN & DEAERATING	545	STEAM JET INTERCOOL.						274				184				363		434		506	519	361 to 520	545
WALDORF	WELLS	EVAPORATION	NO	1	50 - 75	ABOVE TURB. ROOM	44,000	EVAP. VAPOR	OPEN DEAERATING	250	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ATWATER KENT	CITY MAIN	EVAPORATION		2	200 & 45	PUMP ROOM	26 000		OPEN DEAERATING	250	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PROCTER & GAMBLE	CITY MAIN	HOT LIME & SODA & PHOSPHATE	NO	—	—	—	—	AUXILIARY EXHAUST	OPEN DEAERATING CLOSED	220 TO 350	—	—	—	—	—	—	200	220	—	—	220	350	—	—	—	—	—	—	—	—	—	—
AMERICAN ENKA	PROCESS WATER	ALUM & SODA . FILTERED	—	—	—	—	—	EXTRACTION	OPEN	200	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CALUMET & ARIZONA	AIR COMPRESSORS	HOT LIME & SODA	—	—	—	—	—	EXTRACTION	CLOSED DEAERATING	308	101	110	—	—	—	—	202	301	—	—	202	301	110	209	—	—	—	—	—	—	—	—	—	—
WILLIAM WILHEIM	—	—	—	—	—	—	—	RETURNS	OPEN	210	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PT. BREEZE	CITY MAIN	ZEOLITE	—	—	—	—	—	PUMP EXHAUST	OPEN DEAERATING	220	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
BUREAU OF STANDARD	CITY MAIN SOFTENED	ZEOLITE	—	—	—	—	—	—	OPEN DEAERATING	212	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PROXIMITY	FILTER WATER	TRI-SODIUM	NO	NONE	—	—	—	EXTRACTION	OPEN DEAERATING	245	86	140	150	110	80	108	180	245	—	—	12 LB PRESSURE EXTRACTED & BOILER FEED PUMP AT 12 LB. TO HEAT FEED WATER										EXHAUST AT	
UNIVERSITY OF NEBRASKA	CITY WELL WATER	EVAPORATION	NO	1	150	BASEMENT	12 500	AUX. EXH. & EXTRACTION	DEAERATING	210	75	140	75	85	75	88	140	210	210	268	—	—	—	—	—	—	—	—	—	—	—	—
AMERICAN SALPA	DEEP WELLS	COMPOUND	—	—	—	BASEMENT	—	RETURNS	DEAERATING	214	—	—	65	70	65	70	180	214	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CHAMPION COATED PAPER	WELL	HOT LIME & SODA & PHOSPHATE (1)	NO	—	—	—	—	EXTRACTION	OPEN DEAERATING & CLOSED	353 TO 374	—	—					218	250	GLAND COND		250	294 309	294 309	347 389 (2)	CONTINUOUS BLOWDOWN 83 76		WATER TREATMENT 131 128	127	CONTINUOUS BLOWDOWN 347 369	353 374	—	—
TITANIUM PIGMENT	RIVER	HOT LIME & SODA	—	—	—	—	—	EXTRACTION	DEAERATING	210	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

(1) PHOSPHATE INTERNALLY APPLIED (2) UPPER FIGS. SUMMER TEMP. LOWER WINTER



Advancement in Turbine Room Practice

By H. S. WHITON
Chief Mechanical Engineer,
Byllesby Engineering & Management Corp.

THE PAST YEAR has developed no radical departures from the practices evident in the previous year as regards the turbine room; however, progress has been made in refinement and fuller development of practices previously adopted.

High pressures are no longer viewed as experimental. Nearly all engineers consider 1200 to 1400-lb. installations practically as reliable as lower pressure ones and that the choice of pressure for any plant depends upon economic considerations.

High capacity factor and high fuel costs indicate high-pressure installation. Low capacity factor and low fuel cost call for moderate pressure so long as the cost of high-pressure equipment is much in excess of the cost of moderate pressure equipment.

In general, 400 lb. pressure, 750 deg. F. total temperature without reheat is more economical than 600 lb., 750 deg. F. with reheat, since the added fixed charges on the latter will usually more than offset the reduced fuel costs. 1200 to 1400 lb., 750 deg. F. appears to be a more economic choice where reheat is required, since fuel economy is greater in proportion to added fixed charges.

In the vicinity of Chicago, two recent purchases have been made of single shaft machines designed for 1200 lb., 825 deg. F. normal steam conditions, one with rated capacity of 150,000 kw. and one of 125,000 kw. capacity.

Turbines are now regularly designed for 400 lb. capable of withstanding 450 lb. for short periods, and for 600 lb. capable of withstanding 650 lb. for short periods. Intermediate pressures do not fit the manufacturer's standards, hence are not attractive to the power plant designer.

Similarly, turbines are built regularly for 750 deg. F. capable of withstanding 775 deg. F. for short periods, and for 825 deg. F. capable of withstanding 850 deg. F. for short periods. Thus the use of intermediate temperatures is penalized, since the lower temperature design cannot be used with safety and the added cost of

the higher temperature design cannot be fully justified unless the full temperature is utilized.

There is a marked tendency toward simplicity of turbine design as shown by increased capacity of single shaft units now available. At least two units of 200,000 kv-a. capacity in one generator with tandem compound turbine to run at 1800 r.p.m., receiving steam at 400 lb., 730 deg. F. are now being built.

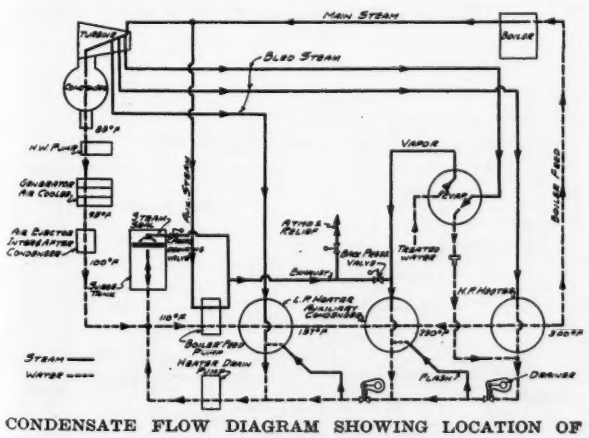
Numerous installations of so-called vertical compound units have been made or are in progress. These units permit a material reduction in floor space per kilowatt installed without much, if any, increase in building height. Where floor space is limited or expensive, these units are attractive in spite of the inconvenience entailed by mounting the high pressure unit directly over the low pressure unit.

That some designers believe further reduction in cost of power house buildings is imperative is evidenced by recent requests to turbine manufacturers to study the possibility of outdoor installations to be remote controlled from an operating room or control house. It is doubtful whether this idea can be worked out satisfactorily for use in severe climates, but it may be feasible in mild climates. Outdoor boiler installations have been common in the tropics for years, although a roof is desirable there to protect the firemen from sunstroke and the brickwork from torrential rains.

Interesting experiments are under way to determine the best materials for turbine blading subject to erosion because of wet steam. Several turbines in regular service have been equipped with groups of blades in the same row, using various materials and various platings or other protective coatings in order to obtain accurate information as to the best method of avoiding erosion under normal operating conditions. The results of these experiments should be of value in prolonging the life of turbine blading in the stages subject to wet steam.

Experiments are being continued with 1000-deg. F. steam. It is apparent that the superheater for this temperature is reliable but no definite statement can be made yet regarding the turbine, as many problems due to creep of metals at high temperatures are yet to be solved.

Successful conclusion of these experiments will pave the way for added economies in fuel, since it is predicted that a decrease of 4 per cent in turbine heat consumption will result from each increment of 100-deg. F. above 750-deg. F. initial steam temperature.



CONDENSATE FLOW DIAGRAM SHOWING LOCATION OF STEAM SEALED SURGE TANK

Herbert S. Whiton, chief mechanical engineer of Byllesby Engineering & Management Corp., Chicago, Ill., received the degree of Bachelor of Science in Mechanical Engineering from Harvard University in 1901. Early in 1905, he entered the employ of Stone and Webster as chief engineer of the power station of the Ponce Railway & Light Co. at Ponce, Porto Rico. At the end of about 2 yr., he was made manager of the company. In July, 1909, he was transferred to the Minneapolis General Electric Co. as superintendent of power, having charge of all power stations and substations and the maintenance and operation of a 60,000-v. transmission line between St. Croix Falls, Wisconsin, and Minneapolis. In June, 1923, he was transferred to the Chicago office of the Byllesby Engineering & Management Corp. He is a member of the American Society of Mechanical Engineers and the Harvard Engineering Society.

The use of steam jet air removal apparatus instead of rotative dry vacuum pumps is increasing, due largely to the reduced space required, simplicity of operation and high thermal efficiency of the steam jet in connection with intercoolers and aftercoolers which return the waste heat to the boiler feed.

Regenerative heating of feedwater is being used more extensively in smaller sized units than before, and evaporators for the supply of pure feedwater are increasingly popular as the use of water walls and high evaporation rates in boilers requires the purest feed obtainable for satisfactory results.

More careful attention than heretofore is now given to the provision of feedwater free from oxygen. Some designers rely on deaerators for the removal of oxygen. Others try to prevent contamination by oxygen and use no deaerators. A system of this type recently installed in several power plants is illustrated in the diagram which accompanies this article. To date, the system is operating satisfactorily in all cases.

Condensate from the condenser hotwell is pumped through the generator air cooler and steam jet air ejector intercoolers and aftercoolers into the boiler feed pump suction header. Floating on this header is a condensate storage or surge tank to handle differences between supply and demand for condensate. To avoid oxygen absorption by the condensate in this surge tank, a blanket of steam is maintained over the water at about ½ lb. gage pressure by a line from the auxiliary exhaust header. This line is equipped with a reducing valve located close to the surge tank. To minimize condensation of this steam blanket, an insulated float is provided covering as much of the water surface as possible.

The surge tank overflow is water sealed in a manner which prevents excessive pressure or vacuum above the condensate in the event of trouble with the supply of blanket steam.

The boiler feed pumps handle water at about 110 deg. F. at full load on the turbine, and deliver through the stage heaters and auxiliary condenser to the boiler feed header.

The auxiliary condenser, which also acts as evaporator condenser, is so placed in the condensate flow

that the shell pressure will be above atmosphere at full load but not over, say, 25 lb. absolute, as the design of the auxiliary turbines would be adversely affected by a greater back pressure.

To avoid possible oxygen contamination of the auxiliary exhaust at partial loads, due to pressure below atmosphere in the exhaust casings, a back pressure valve is installed between the auxiliary exhaust header and the auxiliary condenser. This valve is set to maintain not less than two pounds gage on the exhaust header. The atmospheric relief valve on this header is set to blow at about two pounds above the maximum pressure possible in the auxiliary condenser.

Further to avoid oxygen contamination which might come from the vacuum heating system for the building, a heating system evaporator is employed. Live steam is supplied to the evaporator coils through an automatic valve controlled by the pressure in the evaporator shell. By this device, only oxygen free condensate gets into the feedwater system no matter what conditions obtain in the house heating system, since the drains from the house heating system are the evaporator feed and do not enter the plant feedwater system.

Drips and drains from steam lines are discharged into a receiving tank which is suitably vented. This tank is drained to the condenser through a float type drainer, thus returning these drips to the system practically oxygen free.

Notable Improvements in Heat Balance Layout

ADVANCED DESIGN AND REFINEMENT OF DETAIL NOTICEABLE IN ALL STATIONS, PARTICULARLY IN INDUSTRIAL PLANTS WHERE STANDARDS HAVE ADVANCED UNTIL THEY ARE EQUAL OR PERHAPS SUPERIOR TO CENTRAL STATION PRACTICE

SINCE THE PRACTICALLY universal acceptance of turbine extraction by both central station and industrial engineers, refinements in the heat balance have been taking place so unobstrusively that they have been overshadowed by the more spectacular developments such as the 1000 deg. F. equipment at Delray No. 3 and the mercury vapor equipment at South Meadow. Both of these installations are proceeding nicely and their performance will undoubtedly have considerable influence on station design during the next two or three years.

At Delray the high temperature turbine has been under operation with 750-deg. steam since October 1 and will be operated at 1000 deg. as soon as the high temperature superheater and piping is complete. Reports from the mercury boiler installation at South Meadow indicate a heat rate of 9800 B.t.u. per kw-hr. net for the mercury turbine and its complement of steam capacity while reports from Holland Station show at least one week's operation at a heat rate of 11,866 B.t.u. per kw-hr. which is regarded as a new world's record, beating by a considerable margin the December, 1926 record of 12,495 B.t.u. made at Columbia and the 6 mo. average record of 12,610 B.t.u. advanced by Powerton.

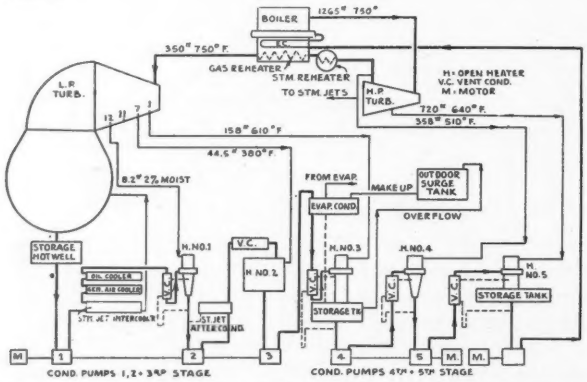


FIG. 1. SOUTH AMBOY USES OPEN HEATERS UP TO A FINAL PRESSURE OF 720 LB. AT RATED LOAD

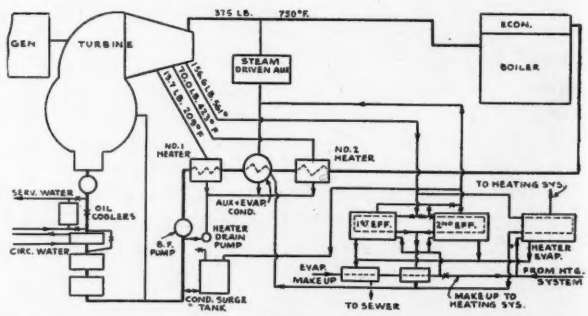


FIG. 2. JAMES H. REED OPERATES ON A TRUE CLOSED SYSTEM

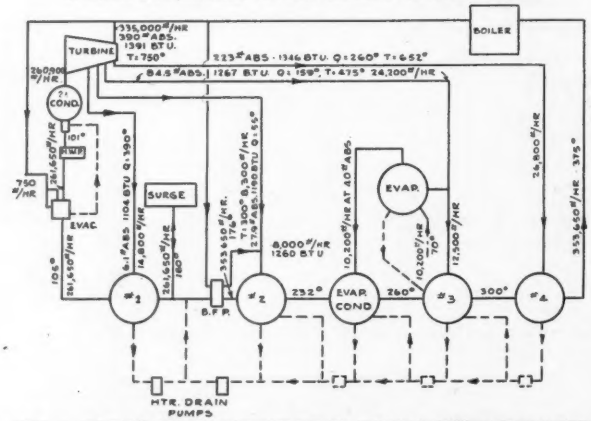


FIG. 3. BELLE ISLE BLEEDS FROM FOUR POINTS BECAUSE OF LIMITED CIRCULATING WATER

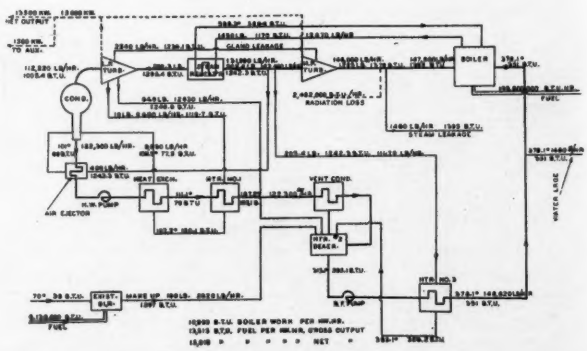


FIG. 4. CONCEPCION ROAD REHEATS AT 200 LB. WITH STEAM

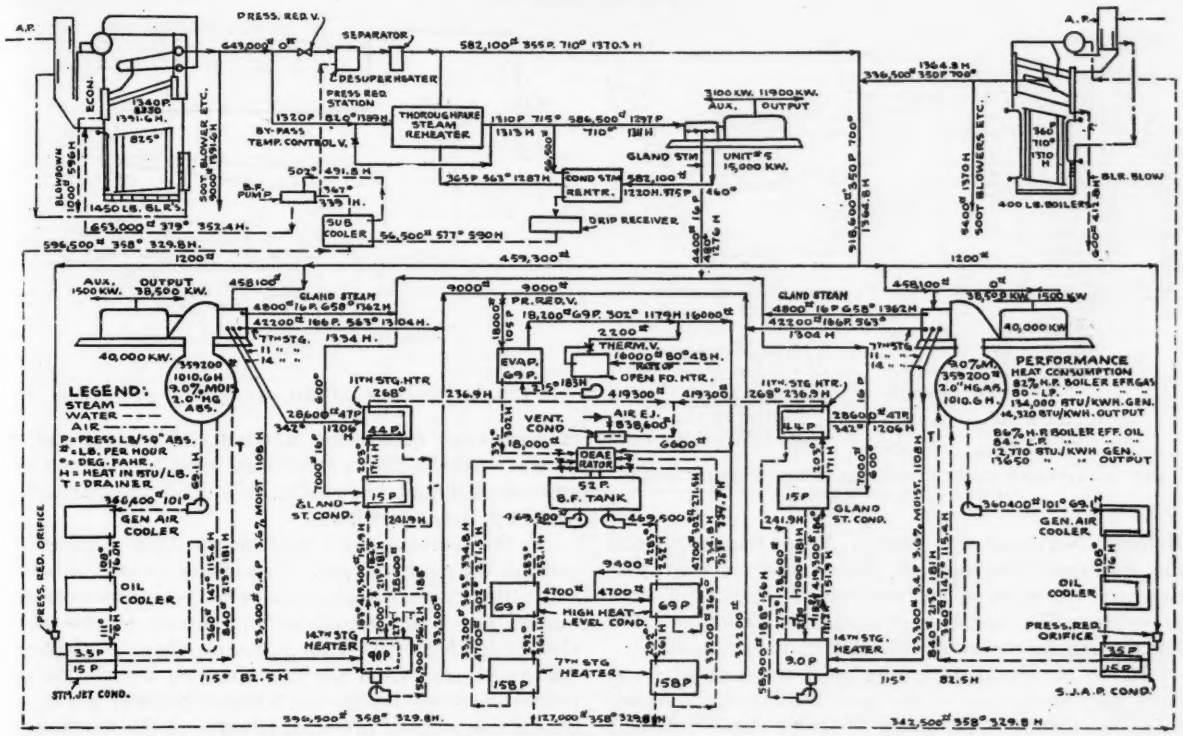
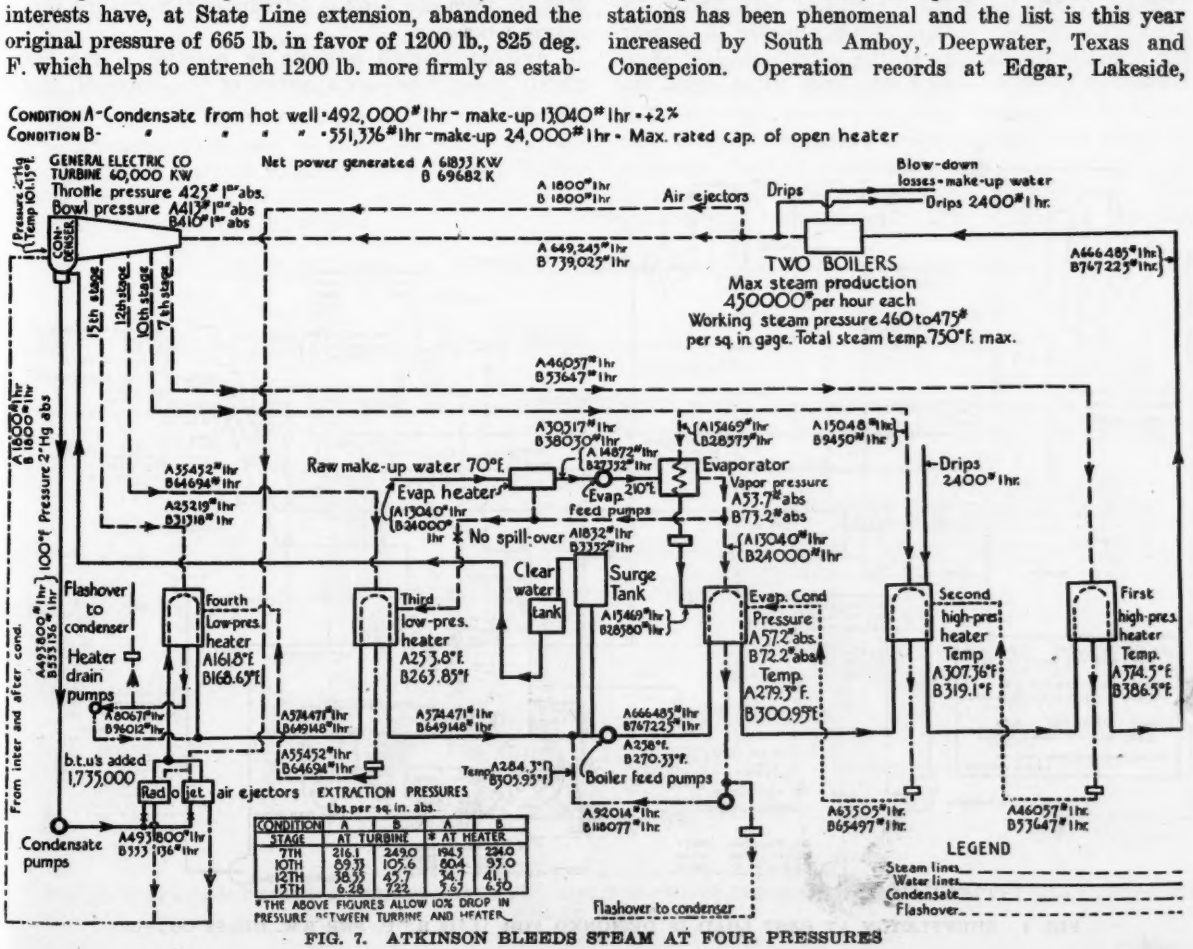


FIG. 5. DEEPWATER SUPERIMPOSES A 1300-LB. SYSTEM AND REHEATS WITH STEAM AT 365 LB.

In spite of this impressive Powerton record, the same interests have, at State Line extension, abandoned the original pressure of 665 lb. in favor of 1200 lb., 825 deg. F. which helps to entrench 1200 lb. more firmly as established practice. In fact, the spread of 1200—1400 lb. stations has been phenomenal and the list is this year increased by South Amboy, Deepwater, Texas and Concepcion. Operation records at Edgar, Lakeside,


CONDITION A - Condensate from hot well • 492,000 #/hr - make-up 13040 #/hr = +2%
CONDITION B - " " " " • 551,336 #/hr - make-up 24,000 #/hr - Max. rated cap. of open heater
GENERAL ELECTRIC CO TURBINE 60,000 KW
Throttle pressure 425# I" abs.
Bowl pressure A413# I" abs B410# I" abs
Net power generated A 61833 KW B 69682 K
Air ejectors
Drips
Blow-down losses - make-up water
Drips 2400#/hr.
TWO BOILERS
Max steam production 450000# per hour each
Working steam pressure 460 to 475# per sq. in. gage. Total steam temp. 750°F. max.
Raw make-up water 70°F.
Evap. heater
Evap. feed pumps
Evaporator
Vapor pressure A53.7# abs B73.2# abs
No spill-over
Clear water tank
Surge Tank
Flashover to condenser
Heater drain pumps
Fourth Low-pres. heater A161.8°F. B168.6°F.
Third low-pres. heater A253.8°F. B263.85°F.
Evap. Cond Pressure A57.2" abs. B72.2" abs Temp. A279.3°F. B300.95°F.
Second high-pres heater Temp A307.36°F B319.1°F
First high-pres. heater Temp. A374.5°F B386.5°F.
b.t.u's added 1,735,000
Rad jet air ejectors
EXTRACTION PRESSURES Lbs. per sq. in. abs.
Boiler feed pumps
Condensate pumps
From inter and after cond.
Flashover to condenser
LEGEND
Steam lines
Water lines
Condensate
Flashover

CONDITION	A	B	A	B
STAGE	AT TURBINE		* AT HEATER	
7TH	216.1	249.0	194.3	234.0
10TH	69.33	105.6	60.4	97.0
12TH	38.55	45.7	34.7	41.1
15TH	9.28	7.22	5.67	6.50

* THE ABOVE FIGURES ALLOW 10% DROP IN PRESSURE BETWEEN TURBINE AND HEATER

FIG. 7. ATKINSON BLEEDS STEAM AT FOUR PRESSURES

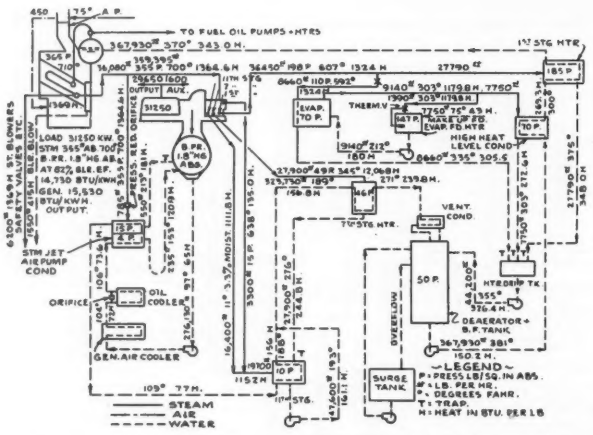


FIG. 6. DALLAS USES A SINGLE EFFECT HIGH HEAT LEVEL EVAPORATOR

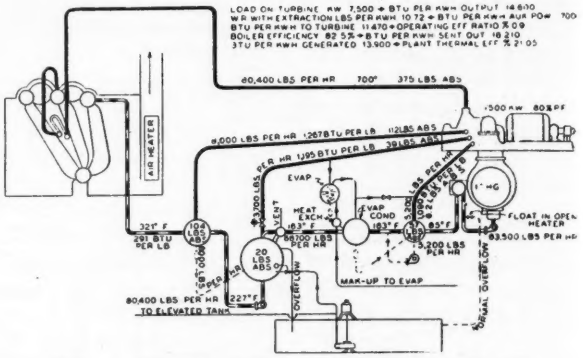


FIG. 9. DEVIL'S RIVER OPERATES AT 375 LB.

Holland, Northeast and Station A are impressive and the continual extension of these older stations, particularly Lakeside, is evidence of the success of high pressures. The new Port Washington station will follow the general design of the later units at Lakeside.

In the industrial field, even more startling advances have been made, two of the most radical developments being the 650-lb. plant of the Waldorf Paper Products Co. at St. Paul, Minn., and the 650-lb. plant of the Champion Coated Paper Co. at Hamilton, O., while the 1800-lb., Carey Co. plant which has been under discussion for the past year or two is reported to be nearing completion. In general, the industrial plant shows marked progress in design standards which equal and in some cases exceed the standards of central station design. All the plants illustrated show an unusual degree of skill and knowledge in solving the particular problems encountered.

In the central station field, South Amboy Station is perhaps the most unusual. In addition to radical boiler and turbine room design, open or jet type direct contact heaters are used throughout in contrast to the usual closed type heater used for pressures above atmosphere. As can be seen from the flow diagram Fig. 1, the extraction pressure for the No. 5 heater is 720 lb. per sq. in. Storage capacity is provided in three of the five heaters and in addition a large underground storage is provided to take the overflow from the No. 3 heater storage tank. Makeup from this tank is introduced through the evaporator condenser.

Another marked advance in practice is the completely closed condensate system of the James H. Reed

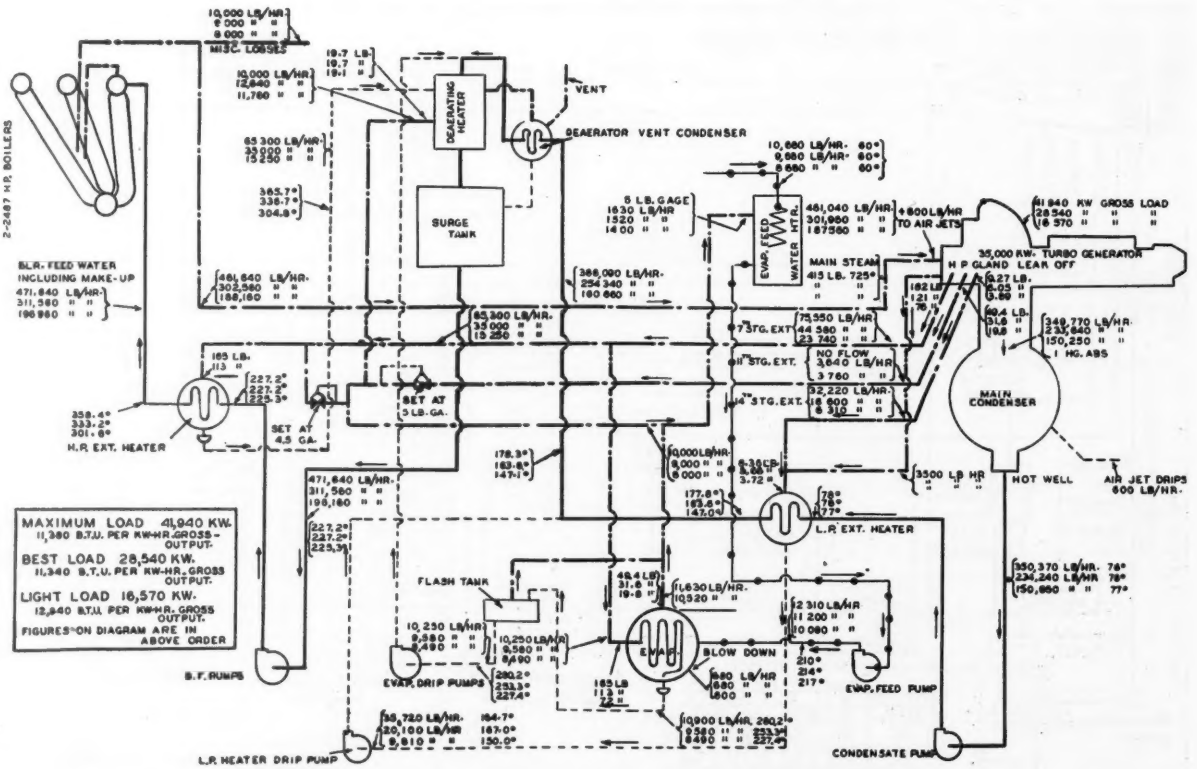


FIG. 8. SHUFFLETON AT BEST LOAD IS DESIGNED FOR 11,340 B.T.U. PER KW. GROSS OUTPUT

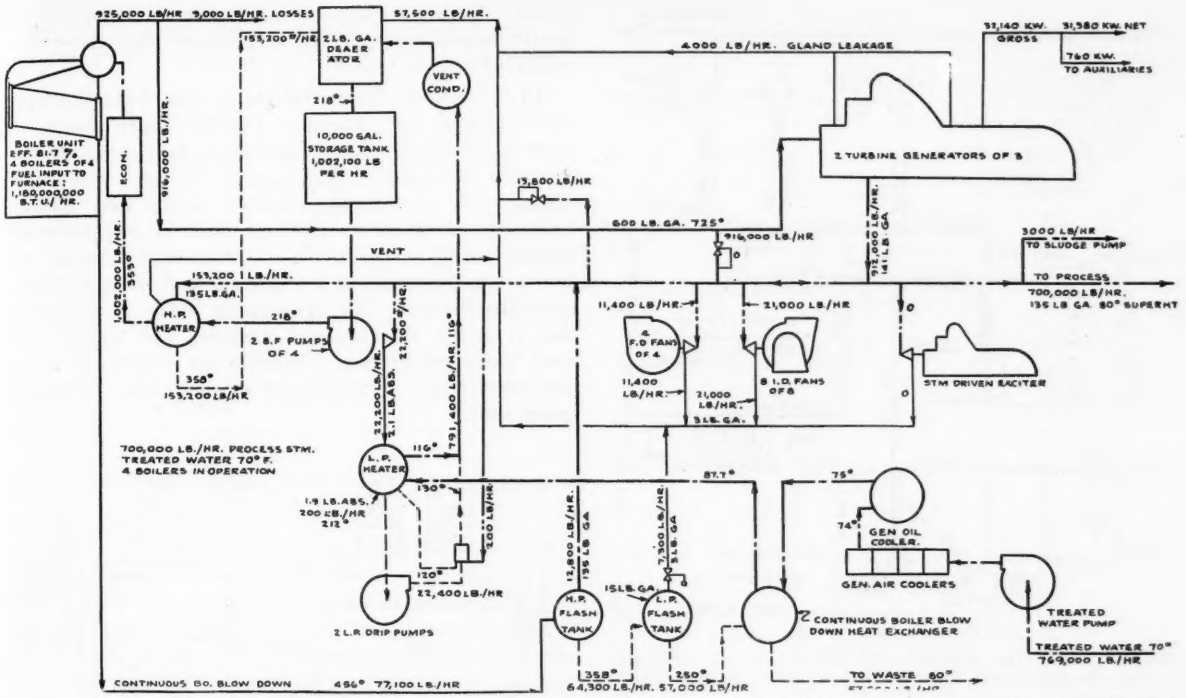

425,000 LB/HR 9,000 LB/HR. LOSSES
57,600 LB/HR.
2 LB. GA. DEAERATOR
VENT COND.
4000 LB/HR. GLAND LEAKAGE
33,140 KW. GROSS
31,380 KW. NET
760 KW. TO AUXILIARIES
BOILER UNIT EFF. 81.7 % 4 BOILERS OF 4 FUEL INPUT TO FURNACE: 1,180,000,000 B.T.U./HR.
ECON.
10,000 GAL. STORAGE TANK 1,002,100 LB PER HR
2 TURBINE GENERATORS OF 3
13,800 LB/HR
600 LB. GA. 725°
916,000 LB/HR
3000 LB/HR TO SLUDGE PUMP
VENT
TO PROCESS 700,000 LB/HR. 135 LB GA. 80° SUPERHT
H.P. HEATER
2 B.F. PUMPS OF 4
11,400 LB/HR.
21,000 LB/HR
F.D. FANS OF 4
I.D. FANS OF 8
STM DRIVEN EXCITER
700,000 LB./HR. PROCESS STM. TREATED WATER 70° F. 4 BOILERS IN OPERATION
L.P. HEATER
GEN. OIL COOLER
GEN. AIR COOLERS
2 L.P. DRIP PUMPS
H.P. FLASH TANK
L.P. FLASH TANK
CONTINUOUS BOILER BLOW DOWN HEAT EXCHANGER
TREATED WATER PUMP
TREATED WATER 70° 769,000 LB./HR
CONTINUOUS BO. BLOW DOWN 456° 77,100 LB./HR
64,300 LB./HR. 57,000 LB/HR
TO WASTE 60°

FIG. 10. LOUISIANA STATION SERVES AN INDUSTRIAL PLANT BUT IS OPERATED BY AND TIED IN WITH THE UTILITY SYSTEM

station made possible by the steam sealed surge condensate tank on the boiler feed suction. This tank is steam sealed either by the evaporator vapor or auxiliary exhaust. Condensate in the tank is separated from the steam blanket by a float. Steam for the heating system is supplied by a separate evaporator. Practically the same arrangement is used at Belle Isle where the need for maximum turbine capacity with limited cooling water facilities made it advisable to bleed the maximum amount of steam from the turbine.

Both of the new 1400-lb. Texas stations are of particular interest because the addition of high-pressure equipment to an existing station is applicable to so many plants. At Deepwater the 1400-lb. equipment is superimposed on the 350-lb. system while at Concepcion Road the high power equipment is operated as a unit with the old equipment tied in simply as a source of make-up. Both of these stations use steam reheaters and fortunately we are able to supply a complete heat balance so that both systems can be studied in detail by

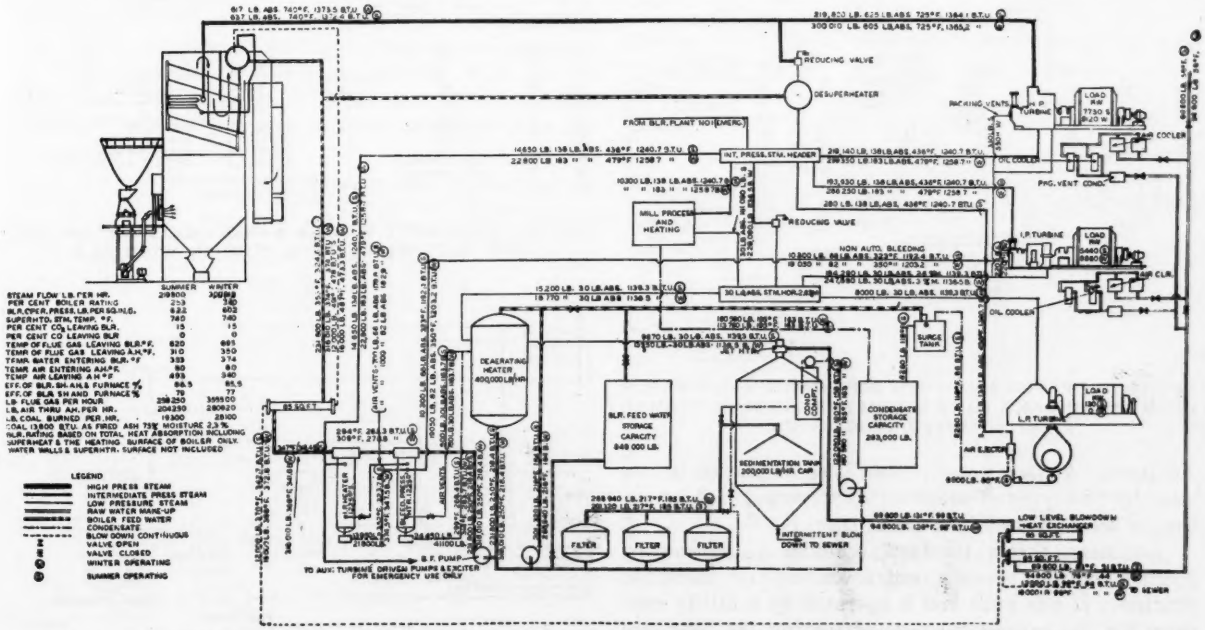


FIG. 12. CHAMPION COATED PAPER OPERATES A TRIPLE ELEMENT TURBINE AND THE LARGEST HIGH PRESSURE BOILER YET BUILT

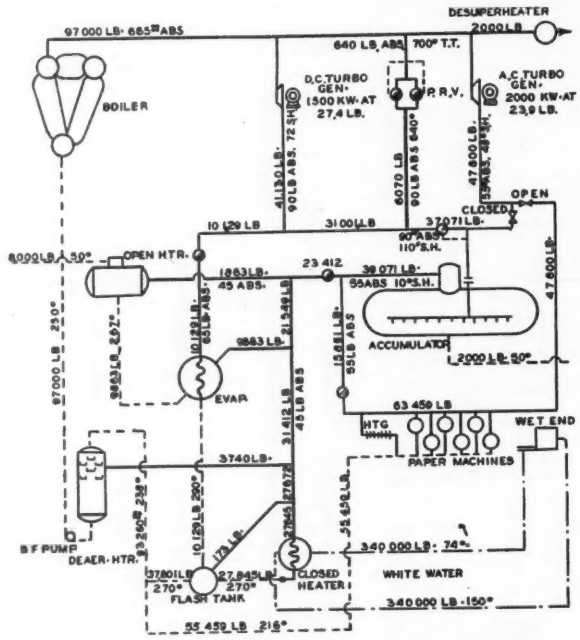


FIG. 11. WALDORF PAPER PRODUCTS USE AN ACCUMULATOR TO BALANCE THE ELECTRIC AND STEAM LOADS

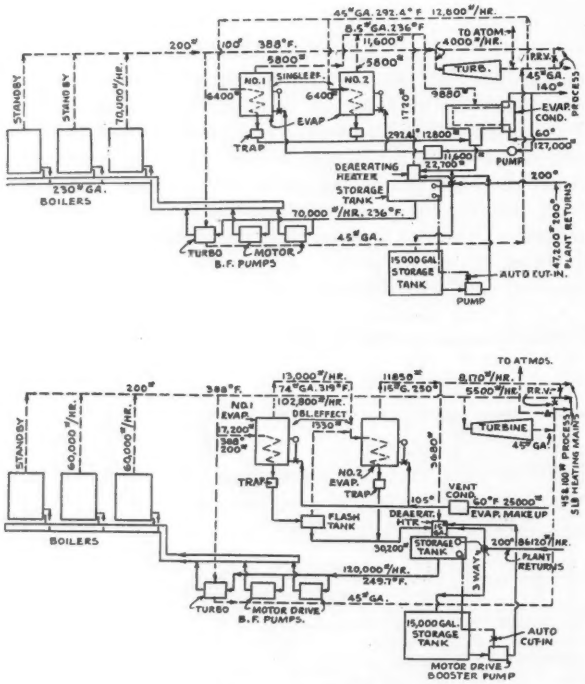


FIG. 13. ATWATER-KENT USE DIFFERENT EVAPORATOR HOOKUPS TO TAKE CARE OF DIFFERENCES IN SUMMER AND WINTER CONDITIONS

designers. At Deepwater, reheat is accomplished in two steps by two types of heaters. At Concepcion Road, reheat is accomplished in a single step.

Louisiana Steam Products occupies an interesting position midway between central station and industrial practice. It was built and is operated by a utility company for the express purpose of serving the Standard Oil Refinery, at Baton Rouge, La., with steam and power. Back pressure turbines exhausting at 156 lb. ga. drive generators which are tied in with the public utility electric system.

In the strictly industrial plants the Waldorf Paper Products and the Champion Coated Paper stand out somewhat from the others because of their complete and thorough treatment. Both are 650-lb. pulverized fuel plants with practically balanced steam and electric loads. At Waldorf a steam accumulator maintains the balance while at Champion a condensing turbine, the low-pressure element of a triple element machine maintains the balance. The Champion plant is unique in that it has a three-element turbine; the largest unit fired boiler yet built and because the entire 500 t. per day paper mill is served by the single turbine and single boiler unit.

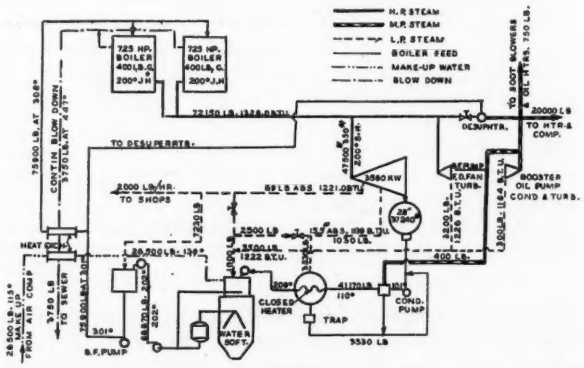


FIG. 14. CALUMET & ARIZONA UTILIZE ALL HEAT SOURCES TO ADVANTAGE

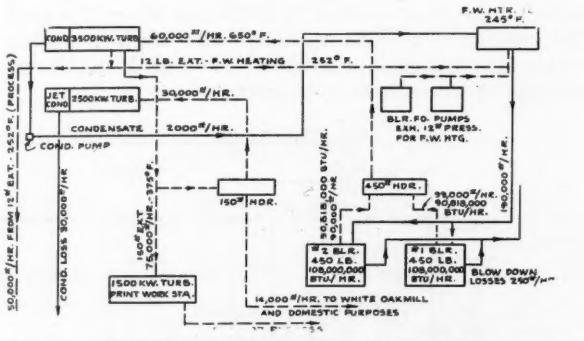

F.W. HTR. 245° F.
COND. 3500 KW. TURB.
60,000 #/HR. 650° F.
12 LB. EXT. - F.W. HEATING
252° F.
JET COND.
2500 KW. TURB.
30,000 #/HR.
CONDENSATE
2000 #/HR.
COND. PUMP
BLR. FD. PUMPS 8 AT 12" PRESS. FOR F.W. HTG.
150# HDR.
450# HDR.
#2 BLR. 450 LB. 108,000,000 BTU/HR.
#1 BLR. 450 LB. 108,000,000 BTU/HR.
BLOW DOWN LOSSES 250°/#
1500 KW. TURB. PRINT WORK STA.
14,000 #/HR. TO WHITE OAKMILL AND DOMESTIC PURPOSES

FIG. 15. PROXIMITY MFG. IS A GOOD EXAMPLE OF THE NEW EQUIPMENT WELL TIED IN WITH OLD

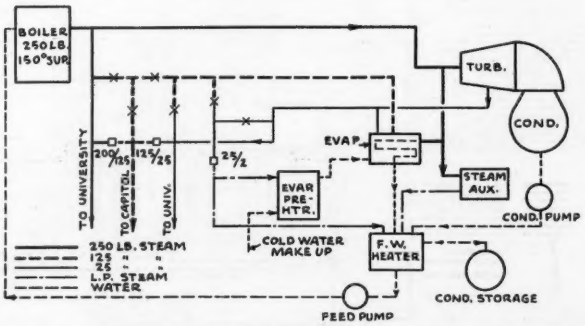


FIG. 16. UNIVERSITY OF NEBRASKA SUPPLIES HEATING STEAM AT THREE PRESSURES

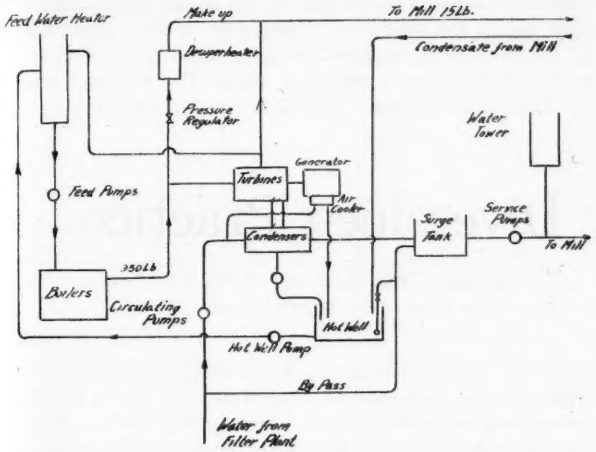


FIG. 17. AMERICAN ENKA USES CONDENSER WATER FOR THE MILL SUPPLY

Another interesting industrial plant arrangement is typified by the Atwater-Kent plant where a back-pressure turbine is operated in parallel with the public utility lines to furnish power up to the requirements of the process steam load. The evaporator arrangement for summer and winter operation is shown by the heat balance. In winter the evaporators, operated single effect, discharge to the heater main. In summer they are operated double effect and the vapor is discharged to a condenser and heats process water.

Industrial plants must of course be designed to meet specific conditions that are peculiar to the particular plants and as such, the heat balance is not of general application although some particular feature may stand out as unusual. For instance, at the Calumet & Arizona heat from air compressor jacket and intercooler water is reclaimed by the plant makeup in a very successful manner.

Another arrangement of interest in this connection is the 465-lb. plant of the Proximity Mfg. Co. where the new 450-lb. condensing turbine is bled at two pressures to supply existing low-pressure turbines with 165-lb. steam and process steam at 27 lb. ga. Another plant where evaporators are used to good advantage is in the

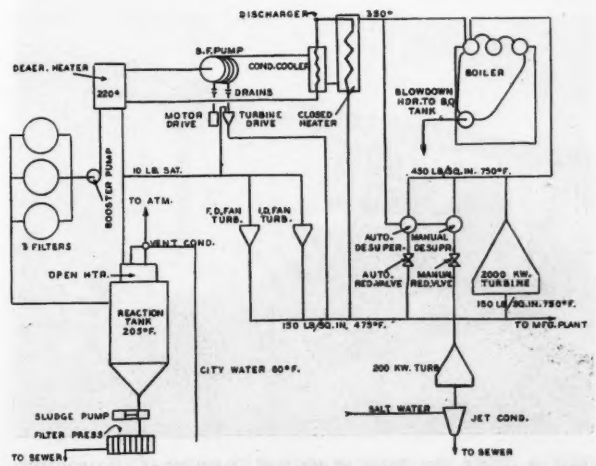


FIG. 18. PROCTER & GAMBLE USES A SMALL CONDENSING TURBINE TO BALANCE THE LOAD

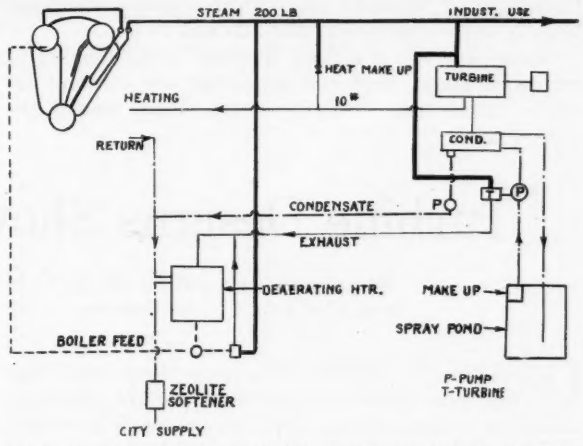


FIG. 19. BUREAU OF STANDARDS USES A SPRAY POND

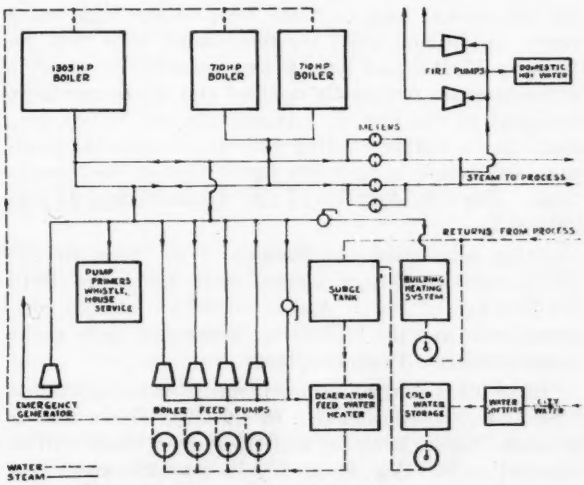


FIG. 20. PT. BREEZE GENERATES NO ELECTRIC POWER

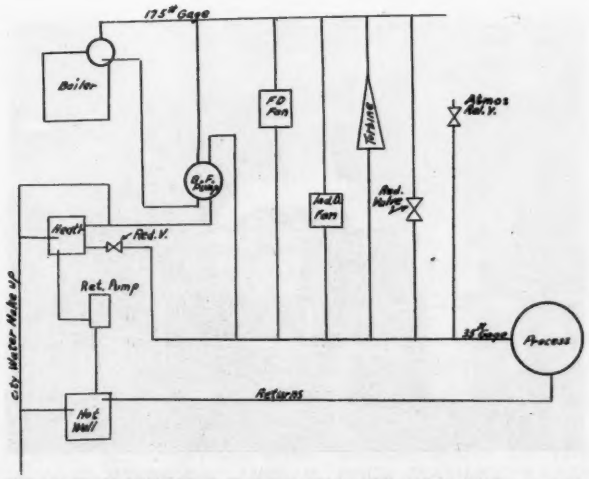


FIG. 21. WILLIAM WILHEIM UTILIZES BACK PRESSURE TURBINES

University of Nebraska plant which supplies steam for heating at three pressures 250, 125 and 25 lb.

Each year sees a definite increase in the number of extraction stages used and a gradual but constant increase in the final feedwater temperature toward the saturated steam temperature of the boiler drum. Industrial plants are losing no opportunity to take advantage of the extraction turbine and have actually reached the point where thermal efficiency misses 100 per cent only by unavoidable boiler, radiation and leakage losses.

Turbine Designs Show Diversified Practice

WIDESPREAD APPLICATION OF 1200—1400 LB. PRESSURES, TEMPERATURES OF 825 AND 1000 DEG. F. AND VERTICAL COMPOUND TURBINES RESULT IN NEW DESIGNS

UNSETTLED PRESSURE, temperature and load conditions have done much to prevent standardization of turbine designs for high pressures and these same unsettled conditions have prevailed for the past few years. For the lower pressure ranges, i.e., 400 and even 600 lb., standardization plans are well under way by all manufacturers. For the time being, the tendency toward increasingly larger units has been checked with the 208,000-kw. unit at State Line as the high water mark. Additional units for this station have been reduced to 125,000 and 150,000 kw. respectively, with the initial pressure practically doubled and the temperature increased to 825 deg. F. Apparently the 160,000-kw., single shaft, double winding generator unit is the maximum size which is desirable under present load conditions. The new unit No. 7 for Hudson Ave. is also 160,000 kw.

Other interesting installations of the year are the 115,000-kw. Waukegan single shaft unit, the Ford 110,000-kw. and South Amboy 25,000-kw. steeple compound units and the 18,750-kw., 3600-r.p.m. units at the Louisiana Steam Products plant.

In addition to the high temperature of the new State Line units, the construction of the 125,000-kw. unit is unusual. Steam from the high-pressure cylinder will be reheated to 825 deg. F. at 400 lb. pressure and again introduced into the high-pressure cylinder for expansion to the crossover pressure of 15 lb. abs.

To the industrial field, the 20,000-kw. triple element unit at Champion Coated Paper is of primary interest. Steam at 615 lb. 725 deg. is expanded to 190 lb. in the high-pressure element and from 190 to 30 lb. in the intermediate pressure element which is also bled at 90 lb. for feedwater heating. Steam for process and feedwater heating is taken from the 190 and 30 lb. crossover lines. The low-pressure conducting element is used primarily as a balancing device between the steam and electric loads. The flexibility of this plant has not yet been exceeded.

Both the Deepwater and Concepcion Road high-pressure turbine units can be studied to advantage by both industrial and central station engineers. The heat balances for both stations are given complete in the preceding article and the steam reheater arrangements used are undoubtedly indicative of future trends, particularly in localities where load conditions demand additional capacity in existing plants where 1200-lb. equipment can be superimposed on or operated in conjunction with existing low or intermediate pressure equipment.

Another turbine which will undoubtedly have a far-reaching influence on plant design is the 10,000-kw., 720-r.p.m., five-stage mercury unit at South Meadow station. A photograph of this turbine is shown in Fig. 1 of the next article. The unit has but two bearings, with the turbine rotor overhung from the generator bearings. The fifth-stage wheel is 11 ft. in diameter at the shroud rings and the buckets are 27 in. long. Velocities of mercury vapor are only about one-third those of steam, necessitating comparatively low turbine velocity of 720 r.p.m.

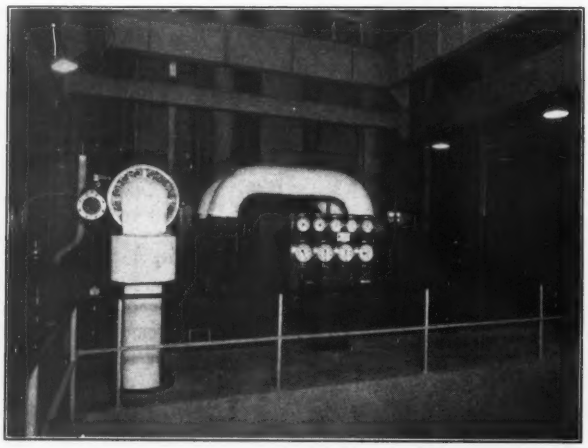


FIG. 1. THE 10,000-KW., 1000-DEG. F. TURBINE INSTALLED AT DELRAY NO. 3

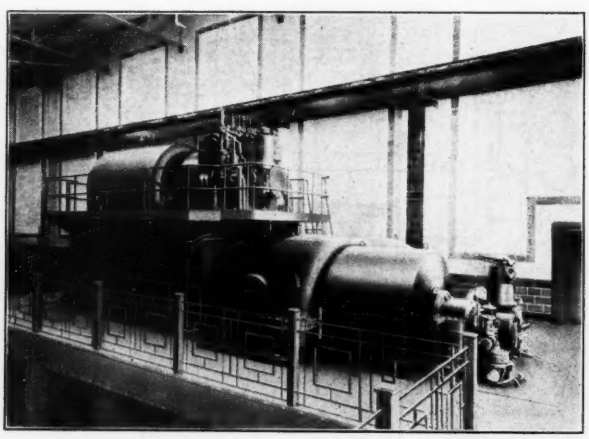


FIG. 2. ONE OF THE 25,000-KW. VERTICAL COMPOUND UNITS AT SOUTH AMBOY

STEAM TURBINES

STATION	NO. & RATED CAPACITY MAIN TURBINE KW.	GENERATOR RATING KW.	DIRECT CONNECTED EXCITER KW.	SHAFT GENERATOR KW.	TYPE TURBINE	SPEED R.P.M.	STEAM CONDITIONS: THROTTLE LB. ABS	THROTTLE DEG. FAHR	REHEAT AT LB. ABS	REHEAT AT DEG. FAHR	EXHAUST PRESSURE ABSOLUTE	STEAM FLOW TO THROTTLE AT RATED LOAD	EXTRACTION AT RATED LOAD: TOTAL LB. PER HR.	PER CENT TOTAL TO THROTTLE	EXTRACTION POINTS: FIRST LB. ABS.	FIRST DEG. FAHR.	SECOND LB. ABS.	SECOND DEG. FAHR.	THIRD LB. ABS.	THIRD DEG. FAHR.	FOURTH LB. ABS.	FOURTH DEG.	FIFTH LB. ABS.	FIFTH DEG. FAHR.	PURPOSE
JAMES H. REED	1-60,000	60,000	200	—	HORIZONTAL SINGLE CYL.	1800	390	725	—	—	29"	584,000	83,430	14.3	13.7	210.9	70	423	156.6	561	—	—	—	—	FEED HEATING & EVAPORATING
BELLE ISLE	1-30,000	35,000	150	—	HORIZONTAL SINGLE CYL.	1800	375	750	—	—	28"	335,000	74,100	22.2	8.1	165	27.9	300	84.5	475	22.3	652	—	—	FEED HEATING & EVAPORATING
RIO GRANDE	1-31,250 1-23,300	25,000 80% P.F. 18,750	135 125	—	HORIZONTAL SINGLE CYL.	1800	440	725	—	—	28.5"	285,000 152,500	66,000 @ 10,300	24.9 @ 6.75	5.1 5.7	163 188	18.5 NOT	226 USED	70 —	428 —	NOT —	USED —	— —	— —	FEED HEATING & EVAPORATING
SHUFFLETON	2-43,000	35,000 80% P.F.	200	—	HORIZONTAL SINGLE CYL.	1800	415	725	—	—	29"	450,000	100,000	22.2	9	130	50	274	182	385	—	—	—	—	FEED HEATING & EVAPORATING
LOUISIANA	3-18,750	15,000 80% P.F.	90	—	HORIZONTAL SINGLE CYL.	3600	615	725	—	—	156 LB.	555,000	—	—	—	—	—	—	—	—	—	—	—	—	—
ATKINSON	1-60,000	60,000	200	—	17 STAGE SINGLE CYL.	1800	425	725	—	—	28"	730 000	177 700	24.0	6.5	173	41.4	320	95	485	22.5	635	—	—	FEED HEATING & EVAPORATING
GREAT WESTERN	1-43,750	43,000	—	—	HORIZONTAL SINGLE CYL.	1800	365	625	—	—	29"	474,000	76,900	16.2	6.72	175	23.5	336	—	—	—	—	—	—	FEED HEATING
DEEPWATER	1-12,000 1-30,000	12,000 80% P.F. 37,500	85 175	—	HORIZONTAL SINGLE CYL.	3600 1800	1297 350	710 700	350	700	28"	458,100 **	94,100	20.5	9.4	3.8% MOISTR	47	342	188	583	—	—	—	—	
DALLAS	1-25,000	25,000	145	—	HORIZONTAL SINGLE CYL.	1800	355	750	—	—	28.2"	281,000	60,900	21.7	8.75	184	38.6	309	155	385	—	—	—	—	FEED HEATING & EVAPORATING
DEVIL'S RIVER	2-3,500	7,500	45	—	HORIZONTAL SINGLE CYL.	3600	375	700	—	—	29"	80,600	18,900	21.0	6.2	170	38	317	112	485	—	—	—	—	FEED HEATING & EVAPORATING
CONCEPCION ROAD	1-20,110	20,110			X. COMP. HORIZONTAL	H.P. 3600 L.P. 1800	1284	810	204	575	28.5"	184,400	40,900	22.15	12.2		118.5		101		—	—	—	—	FEED HEATING
SOUTH AMBOY	2-24,000	25000 80% P.F.	190	—	X. COMP. VERTICAL	H.P. 3600 L.P. 1800	1265	750	350	750	28.5	250 000			8.2	2% MOISTR	44.5	380	158	610	358	510	720	640	FEED HEATING & EVAPORATING
WALDORF	1-1500 DC 1-1,750 AC	1500 1750	25	—	SINGLE CYL.	3540/514 3600	625 625	730 730	—	—	75.9 LB. 55 LB.	40,500 84,000	—	—	—	—	—	—	—	—	—	—	—	—	PAPER DRYING
ATWATER KENT	1-1000	750 50% P.F.	18	—	SINGLE CYLINDER	3600	205	488	—	—	1.80 LB.	36,250	—	—	—	—	—	—	—	—	—	—	—	—	FEED HEATING & PROCESS
PROCTER & GAMBLE	2-2000 1-200	2000 200	15 5	—	SINGLE CYLINDER	3600	415 150	700 490	—	—	165 LB. 28"	104 000 4 800	—	—	—	—	—	—	—	—	—	—	—	—	FEED HEATING & PROCESS
AMERICAN ENKA	2-2500	2200	13	—	MIXED PRESSURE	3600	350	700	—	—	28"				13	300	—	—	—	—	—	—	—	—	PROCESS
CALUMET & ARIZONA	3580	3580	25	—	SINGLE CYLINDER	3600	362	635	—	—	28"	47,500	10,280	21.60	15.5	214	69	380	—	—	—	—	—	—	FEED HEATING & FOR SHOPS
WILLIAM WILHEIM	2-300	300	5.5	—	SINGLE CYLINDER	6000/900	190		—	—	29 in				—	—	—	—	—	—	—	—	—	—	FEED HEATING & PROCESS
PT. BREEZE											BOILER PLANT ONLY														
BUREAU OF STANDARDS	750	750	—	—	SINGLE CYLINDER	3600	210	488	—	—	27	24,000	19,000	79	10	SAT.	—	—	—	—	—	—	—	—	HEATING
PROXIMITY	1-2250 1-4450	2500 3500	20 32	—	SINGLE CYLINDER	3600	400	650	—	—	28.4	160 000	150 000	94	12	280	150	480	—	—	—	—	—	—	FEED HEATING & PROCESS
UNIV. OF NEBRASKA	2-125	1250	16	—	SINGLE CYLINDER	3600	265	256	—	—	29	WITH MAX. EXT. 48 000			4.0	260	—	—	—	—	—	—	—	—	HEATING BUILDINGS
AMERICAN SALAMI	1-750 2-500	750 500	10-0 7-5	—	EXTRACTION	3600	390	842	—	—	29"	21 000 15 050	18 000 15 050	85-0 94-0	30	270	—	—	—	—	—	—	—	—	PROCESS & HEATING
CHAMPION COATED PAPER	20000	HR9375 I.R 9375 L.R 875	40 40 —	—	TRIPLE ELEMENT	3600 3600 1800	615 190 30	725	—	—	190 LB 30 LB 28"	239,800 †	211 800 †	98.2	30 CROSSOVER	24%	6.6	323	138 CROSSOVER	434	—	—	—	—	FEED HEATING & PROCESS
TITANIUM PIGMENT	2-1000	1000 80% P.F.		—	SINGLE CYLINDER	3600	275	800	—	—	16 LB.				36	SAT.	—	—	—	—	—	—	—	—	PROCESS

† SUMMER OPERATION 13,300 KW. LOAD
@ BASED ON A COMBINED GROSS LOAD OF 40,000 KW. 25,000 KW. UNIT SUPPLYING MOST OF THE EXHAUST STEAM FOR BOTH UNITS
** " " " MAX. " OF 55000 " . 40 000 ON L.-P. & 15.000 KW. ON H.P. TURBINE.

Condenser Size Continues to Increase

101,000-Sq. Ft. Single Shell Unit for Hudson Ave. and Increased Use of Vertical Circulating Pumps Most Interesting Development of the Year

NO RADICAL CHANGES in condenser design or practice are apparent from the stations completed during the past year. Both single and double pass designs are widely used and apparently designers are using whichever one they think to be the more satisfactory. Divided water boxes continue to be popular and external air cooler sections are still used to a certain extent. Perhaps the most decided trend is the use of tubes rolled either at both ends or with the inlet rolled and the outlet packed.

No perceptible decrease in the amount of surface per kilowatt of generator capacity is noticeable; in fact, with the exception of the Great Western standby station, the plants listed show a conservative figure, averaging around 1 sq. ft. per kw. of capacity. With the exception of the one station mentioned, all stations show

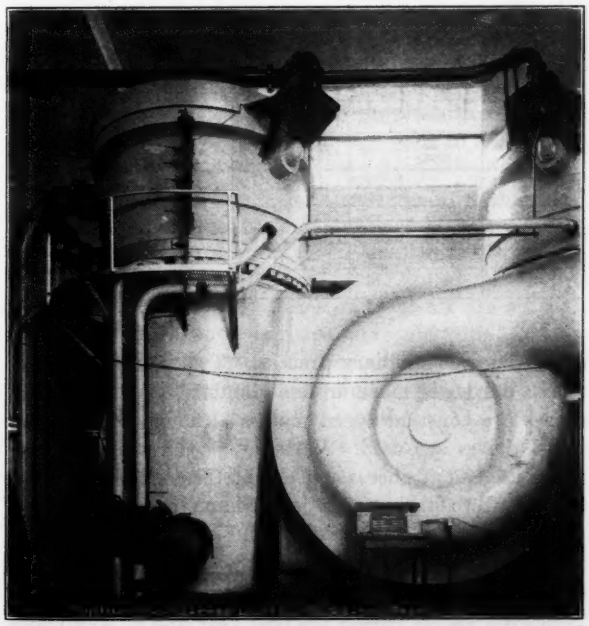


FIG. 1. THE MERCURY CONDENSERS AT THE SOUTH MEADOW STATION (THE MERCURY TURBINE IS THE CIRCULAR ELEMENT IN THE FOREGROUND)

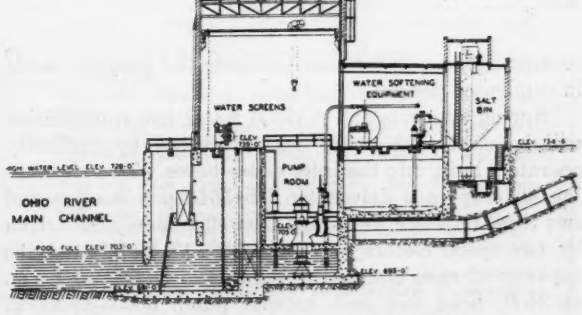


FIG. 2. CIRCULATING PUMP ARRANGEMENT IN THE SCREEN HOUSE OF JAMES H. REED STATION. WATER SOFTENING EQUIPMENT AND TREATED WATER STORAGE IS INCORPORATED IN THE SCREEN HOUSE DESIGN

a condenser loading of less than 10 lb. per sq. ft. of condensing surface in contrast with figures of 15, 11.48, 10.75 and 10.57 shown last year for East River, Station A, Holland and Cahokia respectively.

In this connection the new 101,000-sq. ft. single-pass condensers now under construction for the new 160,000-kw. unit No. 7 at Hudson Avenue is of interest. This is the largest single shell condenser yet built and will have a surface of 0.63 sq. ft. per kw. of turbine capacity. The 7/8-in. o.d. tubes will be 30 ft. long, an impossible length judged by the standards of a few years or even

Another unit of interest is the mercury condenser at South Meadow station. This is made in two sections as shown in Fig. 1 and condenses the mercury vapor exhausted from the 10,000-kw. mercury turbine. The condensing mercury generates steam which is superheated and used in the steam section of the plant. Into the tube sheet of the boiler are welded 559 3-in. dead end tubes which project 14 ft. down into the vacuum or mercury vapor chamber.

With the exception of the increased popularity of the vertical circulating pump, no important change has

CONDENSERS AND AUXILIARIES

STATION	TURBINE RATING KW.	TOTAL SURFACE IN SHELL		AIR COOLER SECTION		STEAM TO CONDENSER AT RATED LOAD LB. PER HR.	PASSES	TUBES	PACKING	EXPANSION JOINT OR SOLID CONNECTION TO TURBINE	CIRCULATING PUMPS					CONDENSATE PUMPS			VACUUM PUMPS		
		SQ. FT.	SQ. FT. PER KW.	INTERNAL OR EXTERNAL	SURFACE SQ. FT.						NO.	CAP. EACH G.P.M.	DRIVE	MAX. G.P.M. PER K.W.	RATIO LB. WATER PER LB. STEAM	NO.	CAP. LB. PER HOUR	DRIVE	NO.	TYPE	TOTAL CAPACITY C.F.M.
JAMES H. REED	60,000	53,000	0.916	INTERNAL		301,570	1	7/8" O.D. X 24'-0" 18 B.W.G.	INLET ROLLED OUTLET PACKED	EXPANSION JOINTS	2	40,000	575 R.P.M. 2300 V. IND. MOTOR	1.33	79.8	2	560,000	STEAM TURBINE	1	TRIPLE 3 STG. STM. JET	63 C.F.M. AT 29" 70 °F.
BELLE ISLE	30 000	33 000	1.10	INTERNAL		260,900	2	1" O.D. X 22'-0" 18 B.W.G. ADM	ROLLED BOTH ENDS	EXPANSION JOINT	1	38,000	194 R.P.M. 2300V. VERT. SQ. CAGE IND. MOT.	1.27	73.1	1	300,000	440V. CONSTANT SP. SQ. CAGE IND. MOT.	1	TWIN 3 STG. STEAM JET	21 C.F.M. 28" 82°F.
RIO GRANDE	1-31 250	25,000	0.80	EXTERNAL	776	199,000		7/8" O.D. X 20'-0" 18 B.W.G. ADM.	ROLLED INLET OUTLET PACKED	SPRING SUPPORTS	2	20,000 IN 2 000 TOT.	CONSTANT SPEED MOT.	0.94	74.7	2	350,000	CONST. SPEED MOTORS	2	2 STG. STEAM JET	750 LB./HR. 29.6" 70°F.
	1-23 500	24,700	1.05	INTERNAL		142,200		1" O.D. X 18'-2 1/2" 18 B.W.G. ADM.			2	17 500 28,000 TOT.		1.34	111.0	2	273,000		2		230 LB./HR. 28" 70°F.
SHUFFLE-TON	2-43,000	40,000	1.07	INTERNAL		350,000	2	7/8" O.D. X 20'-3 1/2" 18 B.W.G. ADM.	INLET ROLLED OUTLET PACKED	SOLID CONNECTION SPRING SUPPORT	2	30 500 60,000 TOT.	CONSTANT SPEED MOTOR	1.4	85.9	2	375,000	CONST. SPEED MOTOR	2	2 STG. STM. JET	166 LB./HR. 29" 70°F.
LOUISIANA	3-10 750								BACK	PRESSURE	OPERATION										
ATKINSON	60,000	70,000	1.17	INTERNAL		581 300	2	1" O.D. X 22'-3" 18 B.W.G. MUNTZ	INLET ROLLED OUTLET PACKED	SOLID CONNECTION SPRING SUPPORT	2	43,000	257 R.P.M. 300 HR 2300 V. CONST. SP. IND. MOTOR	1.43	76.2	2	603,000	1150 R.P.M. 125 HR 2300 V. CONST. SP. IND. MOT.	2	2 STG. STM. JET	490 LB/HR 28" 101°F.
GREAT WESTERN	43,750	27,400	1.8			397,100	1	7/8" O.D. 22'-0" 16 B.W.G. ADM.	ROLLED BOTH ENDS	SOLID CONNECTION SPRING SUPPORT	2	35,000	182/315 R.P.M. 2300 V. IND. MOTOR	1.88	88.2	2	573,000	CONST. SP. 2300V. IND. MOT.	2		
DEEPWATER	35,000	35,000	0.847	EXTERNAL	500	361,000 #	1	7/8" O.D. 24'-0" 18 B.W.G. ADM.	ROLLED BOTH ENDS	EXPANSION JOINT	2	41,000	360/257 R.P.M. 2200 V. IND. MOTOR	2.19	112.5	2	440,000	2200 V. CONST. SP. IND. MOT.	2	2 STG. STM. JET	22-2 C.F.M. 28" 70°F
DALLAS	25,000	38,800	1.58	INTERNAL	17,850	220,100	2	7/8" O.D. 22'-0" 18 B.W.G.	ROLLED BOTH ENDS	EXPANSION JOINT	2	21,000	386 R.P.M. 440 V. CONST. SP. IND. MOTOR	1.66	95.9	2	310,000	440 V. CONST. SP. IND. MOT.	2	2 STG. STM. JET	36.2 C.F.M. 29.5" 73°F.
DEVILS RIVER	7,500	10,000	1.33	INTERNAL	2000	63,500	2	7/8 O.D. 16'-3" 16 B.W.G. ADM.	INLET ROLLED OUTLET PACKED	EXPANSION JOINT	1	12,000	440 V. CONST. SP. INDUCTION MOTOR	1.60	94.5	2	99,600	440 V. VAR. SP. IND. MOTOR	2	2 STG. STM. JET	200 C.F.M. 28.58" 80°F.
CONCEPCION ROAD	20,110	22,500	1.12	INTERNAL		143,500	2	1" O.D. 19'-0" 16 B.W.G. ADM.	PACKED BOTH ENDS	EXPANSION JOINT	2	15,700	1 MOTOR 1 TURBINE	1.56	109.0	2	190,000	VAR. SP. MOTORS	1	TWIN 2 STG. STM. JET	20 C.F.M. 70°F.
SOUTH AMBOY	25 000	20 500	0.82				1	7/8" O.D. 20'-0" 18 B.W.G. ADM.	ROLLED BOTH ENDS	SPRING SUPPORTS	2	14,000	200 R.P.M. 440 V. 100 HP. MOTOR	1.12		2 COMB. WITH	225,000 *	1800 R.P.M. 75 HP. 440 V. MOT. ST R. PUMP		TRIPLE 3 STG. STM. JET	
WALDORF	1500 3750								BACK	PRESSURE	OPERATION										
ATWATER KENT	1,000								BACK	PRESSURE	OPERATION										
PROCTER & GAMBLE	2-2000 1-200								BACK	PRESSURE	OPERATION										
AMERICAN EMKA	2-2500	2200	1.14	INTERNAL			1	3/8" O.D. 18'-0" 18 B.W.G. ADM.	PACKED BOTH ENDS	EXPANSION JOINT	2	3,000	MOTOR	2.4		3	8,400	MOTOR	1	2 STG. STM. JET	10.35
CALUMET & ARIZONA	3650	5350	1.47	INTERNAL		37,240	2	7/8" O.D. 18'-0" 18 B.W.G. ADM.	INLET ROLLED OUTLET PACKED	SOLID CONNECTION	1	8000	690 R.P.M. 2200 V. INDUCTION MOTOR	1.66	82.2	2	45,000 70,000	1750 R.P.M. IND. MOT. 3780 R.P.M. TURBINE		TWIN 2 STG. STEAM JETS	20 C.F.M. 28" 100°F.
WILLIAM WILHEIM	2-300								BACK	PRESSURE	OPERATION										
POINT BREEZE									BACK	PRESSURE	OPERATION										
BUREAU OF STDS.	750	1200	1.60			12,000	1	12'-2" LONG MUNTZ METAL	INLET ROLLED OUTLET PACKED	EXPANSION JOINT	1	1540	1720 R.P.M. TURBINE	2.05	63.0	1	18,000	IND. MOTOR	1	STEAM JET	8 C.F.M. 27.5"
PROXIMITY	1-2500 1-3500	JET 6000	1.71	INTERNAL				3/4" O.D. 18'-0"	PACKED BOTH ENDS	EXPANSION JOINT	2	10 000 TOTAL	MOTOR	1.28		1	50 000	MOTOR	2	2 STG. STM JETS	
UNIVERSITY OF NEBRASKA	1,250	3,000	2.40	INTERNAL		17,000 MAX. ST. CONDENSING	2	3/4 O.D. 14'-0" MUNTZ	PACKED BOTH ENDS	EXPANSION JOINT	1	3,200	50 HP. 220 V. CONST. SP. IND. MOTOR	2.56	94.0	1	25,000	220 V. CONST. SP. MOTOR	1	TWIN 2 STG. STM. JET	11.3 C.F.M. 29" 70°F.
AMERICAN SALPA						10,150 STR. CONDENSING 4100															
CHAMPION COATED PAPER	20 000	3500	0.175	INTERNAL		8000 †	1				CIRCULATING WITH		PUMPS IN MILL	SEPARATE PUMPS	BLDG.	1		75 H 440 V. 3500 RPM MOTOR	1	TWIN 2 STG. STM. JET	
TITANIUM PIGMENT									BACK	PRESSURE	OPERATION										

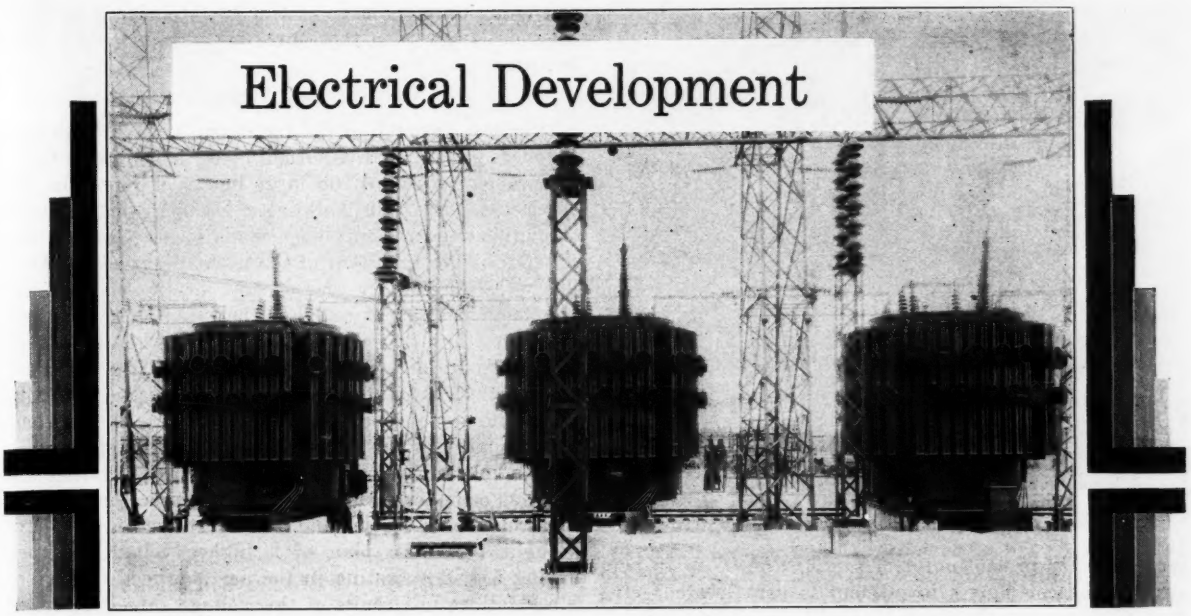
* BASED ON 60,000 KW. LOAD † SUMMER OPERATION 13,300 KW. LOAD

months ago, a point which indicates the progress made in condenser design.

Spring supports and divided water box construction will be used with water control valves, hydraulically operated, built into the inlet water boxes. Two circulating water pumps driven by 225/164-r.p.m. motors and two three-impeller, two-stage hotwell pumps also driven by two speed motors will be used. At high speed the capacity of each circulating pump will be 73,250 g.p.m. at 24-ft. head and each hotwell pump 3000 g.p.m. at 180-ft. head. Air removal will be by a two-stage, triple steam jet, each element of which will have a capacity of 10.8 c.f.m. of dry air at 71.6 deg. F.

taken place in auxiliary practice. Two pumps per unit, motor driven is more or less standard practice. Most drives are constant speed motors although some multi-speed drives are used. Variable speed motors are also being used to an increasing extent for condensate motor drives. Two-stage steam jet vacuum pumps still predominate in spite of recent gains made by the three-stage units.

Screen house design has been the subject of considerable discussion during the past year and it is probable that a modified design with a short screen following the pump will be the next step forward.



Generation, Transmission *and* Distribution

By H. R. Woodrow

Electrical Engineer, Brooklyn Edison Co., Inc.

IMPORTANT PROGRESS has been made during the last year or two in the coördination and planning of the generation, transmission and distribution systems, on the basis of comprehensive developments over projected periods of growth approximating a decade.

The slogan of more kilowatts per dollar adopted by the Engineering Section of the National Electric Light Association, and the formulation of the Power Systems Engineering Committee of that organization, has undoubtedly been a factor in stimulating more thought and study into the comprehensive analysis of the overall problem of supplying the load to the customer. Prejudices of long standing have been cast aside in numerous cases and new lines of thought have been developed.

These comprehensive reviews have revealed the fact that it is not the generating station bus where continuity of service must receive the maximum attention, but rather the customer's service line. In many of our developments of today, the continuity of service on the customer's supply lines, receives more attention and is of greater importance than the continuity of service on the individual generating station buses. The generating station bus is no longer made the center of the system, with the concentration of large blocks of power at this location. Not only has this revision of thought provided increased continuity of service to the customer, but the requirements for high rupturing duty oil circuit breakers and massive bus constructions have been greatly simplified.

In analyzing the problems confronting the electric utility company, one usually thinks first of the generating station because of its massive pieces of machinery. Although the generating station provides a fascinating subject for discussion, the transmission and distribution problem is in reality the more important as it is the

Mr. Woodrow, the author of this article, was born at Luverne, Minnesota, on April 15, 1887. In 1909 he was graduated from Drake University with the degree of B.S. and in 1911 from the post-graduate school of the University of Illinois with the degree of M.S. He held a scholarship in the department of physics of the University of Illinois from 1909-1910 and a fellowship in the same department from 1910-1911. He was appointed to both Sigma Xi and Tau Psi in 1911, and to Phi Beta Kappa, 1924.

He has held positions, and served on committees as follows:

Assistant to the Chief Electrical Engineer, New York Edison Co., 1911-1917.

Assistant Chief Electrical Engineer, New York Edison Co., 1917-1920.

Electrical Engineer with Stone & Webster, Inc., 1920-1922.

General Engineer, Westinghouse Electric & Mfg. Co., 1922. Assistant Electrical Engineer, Brooklyn Edison Co. Inc., 1922-1926.

Electrical Engineer, Brooklyn Edison Co., Inc., 1926 to date.

Chairman, Protective Devices Committee, American Institute of Electrical Engineers, 1921-1925.

Chairman, Electrical Apparatus Committee, National Electric Light Association, 1926-1927.

Member, Committee on Electricity, Distribution and Use. Association of Edison Illuminating Cos., 1924-1928.

Chairman, Sectional Committee on Lightning Arresters, American Engineering Standards Committee, 1924.

Member of the Executive Committee of the Standards Committee, 1925-1928.

Member, Committee on Electric Switching and Switch Gear, Association of Edison Illuminating Companies, 1927 to date.

Member, Executive Committee, Engineering Section, National Electric Light Association, 1928 to date.

Chairman, Power Transmission and Distribution Committee, 1928-1930.

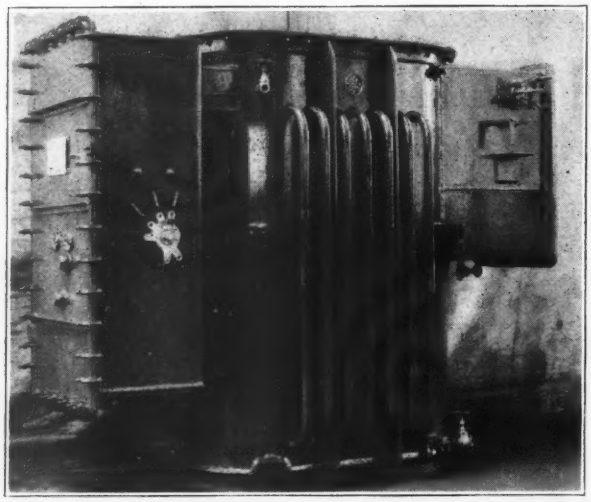


FIG. 1. A 500-KV-A. SUBWAY TRANSFORMER

largest factor in continuity of service and 65 to 75 per cent of the company's investment is here located. In fact, the average utility company will spend more money in a year on service meters than on turbo-generators. These factors lead me to start the discussion of these problems from the customer's end of the system.

In this country, the trend is toward the universal service of three-phase alternating current type, with portable utilization devices supplied from 115 to 125-v. on single phase and 200 to 240 v. on three-phase operation. The selection of the service voltage at 100 plus, by the pioneers more than a half century ago, was very fortunate, as tests and operating experience have proven that street circuits can be relied upon to clear fault troubles at this voltage, when backed by sufficient power to produce the natural magnetic blowout. Operating experience has confirmed the theory that larger mains can be successfully cleared with correspondingly larger short circuit currents resulting from the greater capacity when supplied by the larger transformers and supply circuits.

Continuity of service to the customer has therefore dictated a rapid increase in the policy of supplying this service from 120-v. mains in the street, which mains are, in turn, served from relatively high capacity transformers and high voltage transmission lines. Since reasonably uniform voltage regulation is essential and the load density increases each year, the capacity of the supply lines and mains is naturally increasing, and this has been particularly true during the last year's operation. The expansion of the system, with increasing load densities, has produced a greater incentive to extend the network grid of low voltage mains over wide areas, which has made possible a system with a number of supply feeders to maintain adequate service in cases of primary feeder outages.

The progressive development of the automatic network switch and transformer equipment has been marked during the past year and it has been found possible to increase the voltage on the supply feeders, giving the resulting greater economy and closer voltage regulation. Although the combination of network switches and transformers has been used in the past, the progress in this direction during the past year has been noticeable and today units as large as 600 kw. are placed in manholes no larger than those previously required for 250-kw. units.

Vertical A.C. Networks

Increased growth of tall buildings, involving vertical distances greater than a normal block, has brought forth the problem of supplying large blocks of power in the upper portion of the building. Economy and voltage regulation requirements have made it necessary to use voltages higher than that of the normal service of 120 v. The very satisfactory performance of the network development has therefore led to the extension of the network into the building and up vertically, locating step-down transformers on the upper floors of the building. Several installations of this type have been placed in service during the past year and experience so far has, by wide margins, justified this method of supply.

In the suburban territories where load densities are small as compared with city developments, the exacting requirements of service and lower installation cost, have brought forth the plan of a higher voltage network having a grid operating in the neighborhood of 4000 v. Since failure in circuits of this voltage cannot be relied upon to burn clear, it has been necessary to provide switches to sectionalize automatically a portion of the grid that may become defective. Further thought and study of this line of development, which is in its infancy, will determine the conditions under which it would be more desirable than that of the 120-v. network previously described.

There is little that can be said in regard to progress

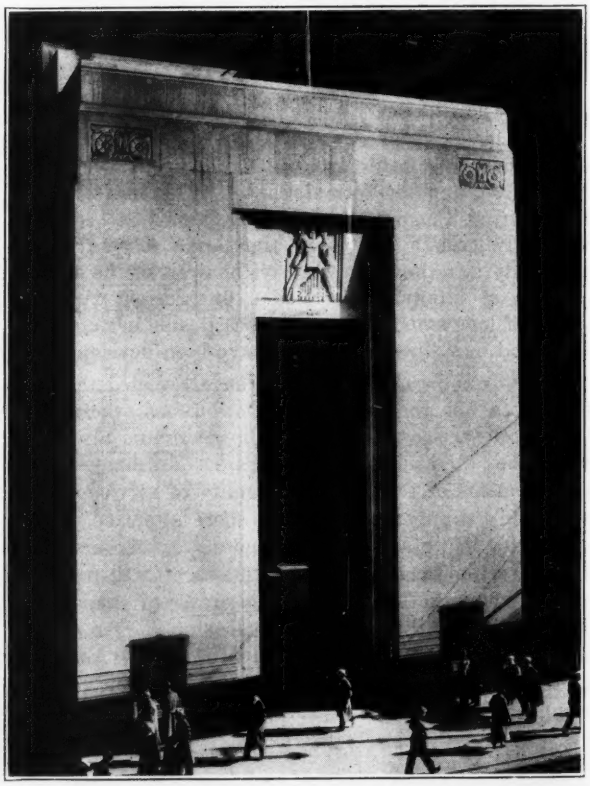


FIG. 2. AN EXCELLENT EXAMPLE OF MODERN METROPOLITAN DISTRICT SUBSTATION DESIGN—THE NEW DEARBORN ST. SUBSTATION OF THE COMMONWEALTH EDISON CO., CHICAGO

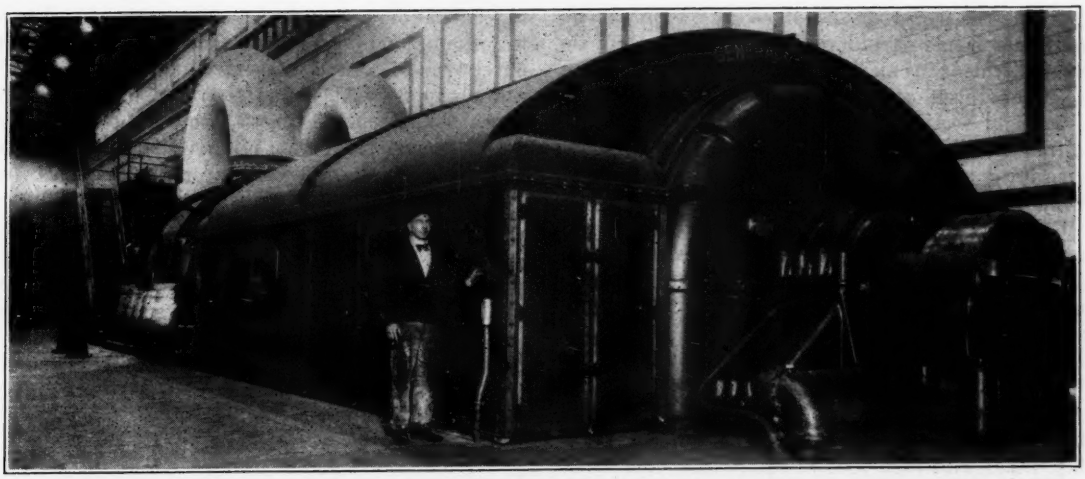


FIG. 3. THE 160,000-KW. SINGLE-SHAFT GENERATING UNIT AT EAST RIVER STATION WHICH WENT INTO SERVICE THIS YEAR

in the development of low voltage cable for street mains at 120 v., although a considerable amount of research work is being done on the development of a type of cable for this class of service, which will permit higher temperature operation for overload conditions. A few installations have been made with rubber-insulated cable for street mains, and the elimination of the lead sheath. Further investigations are under way to determine to what extent this type of installation might be extended as the elimination of the lead sheath results in considerably lower cost and it is felt by some to improve the clearing characteristics on cable failures.

High Voltage Cable

The progress made in the production of high voltage cable, both from the design of the cable standpoint and the control of production processes, has produced a high voltage cable today considerably superior to that of a few years ago. As an example, the report of the Underground Systems Committee of the National Electric Light Association for the year 1929, showed that, on an inspection of over 9,000,000 ft. of paper-insulated cable, the trend in the percentage of deficient cable had dropped from 20 per cent in 1923 to less than 3 per cent in 1929.

Large extensions have been made on cable installations of the 27,000 to 33,000-v. class. The metal sheathed type of three-conductor cable has shown the greatest progress in this voltage rating. The introduction of oil reservoirs on 33,000-v. cable has been of considerable assistance in reducing the failures, and where manhole conditions have made it possible, to use the oil reservoirs to maintain pressure within the cable above atmosphere. In such cases the two old enemies—moisture and voids—have largely been driven from the cable system. The voids have apparently been filled with the oil, and moisture has been prevented from entering the cable by the maintnance of pressure above atmosphere.

The use of oil reservoirs on cable has been further improved by the introduction of channel lines along the cable to give a more easy flow of the oil, as represented in the so-called oil-filled cable class. The installation of these oil channels has made it possible to extend the use of three-conductor cable to as high as 66,000-v. operation, and a little of this cable is now in operation, giving very satisfactory results. Extensions were made during the past year in the extra high-voltage conductor cable operating at 132,000 v., and the performance has been remarkably fine. This progress has led engineers to plan on more extensive use of this system and has given them confidence to extend the range of cable operation to an almost unlimited voltage where load and economy conditions would be the limiting factors.

In large metropolitan districts, the introduction of the network has limited, to a very large extent, the necessity for substations, and in many cases where networks have been expanded, it has been possible to withdraw some of the existing substations. Where substations are required, automatic equipment has been largely used in new installations even where the substation may have an attendant, but the trend has seemed to be in the direction of making the station completely automatic and eliminating the attendant.

Much thought and study have been given to the problem of insulating and protecting transmission lines against lightning disturbances. The development of the lightning stroke recorder and the cathode ray oscillograph, has made it possible to collect valuable information on the characteristics of lightning and its effect upon transmission lines. This progress has been effectively presented at the symposium meetings during the last American Institute of Electrical Engineers' annual convention and the last two Mid-Winter Conventions. Transmission engineers have set out to develop a transmission line which can be considered lightning-proof and considerable progress has been made in the protection against both induced surges and direct strokes.

At the generating station, the greatest progress has been made in the direction of continuity of service by more effectively segregating the bus sections, thereby reducing the amount of disturbance that can result from trouble on any bus section. With the increase in size of units, it has been found desirable to subdivide the generator windings so that the capacity of a bus section may be less than the size of one unit. As an example, the 160,000-kw. unit installed last year in the East River Generating Station is divided into two sections, giving a bus section capacity of 80,000 kw. Units of 200,000-kv-a. capacity with subdivided windings, have been or-

dered during the past year and plans are under way for future developments on units of larger sizes having the windings divided in more than two sections. Some engineers are even considering a subdivision into as many as eight sections. It is of interest to note that within the last two years, the combined systems of all the generating stations in Greater New York have been interconnected with generating capacity of nearly 2,000,000 kw. and the interconnections have been made in such a way so as not to increase the maximum short circuit on the system.

Introduction of truck or semi-truck type of electrical equipment, made several years ago, has gone forward in rapid strides, providing safer operating conditions and requiring less labor for its installation. The "Safety First" slogan has resulted in greater attention to protecting the workman and operator from coming in accidental contact with high tension equipment. Interlocks have been provided on doors and switches so as to make the equipment as foolproof as possible. Not only has the high tension wiring been guarded by insulation, but numerous installations have gone a step farther in providing a grounded metal sheath around the high tension circuits. As an example of this progress, there has been a trend in the elimination of exposed high tension terminals on transformers of the medium voltage class, by having the connections made within the transformer case or an oil-filled box attached to the transformer.

Electrical driven auxiliaries in power plants have increased in favor over the steam drive and, with very few exceptions, all recent installations have been made of this type. There have been a few cases, however, where steam-driven auxiliaries were installed to meet a special heat balance condition, as desirable bleeding points had not been provided on the main turbo-generator units. The introduction of vane control on forced and induced draft fans to regulate the air pressure has simplified the motor requirements for these units. Installations of this class have given satisfactory performance, both as to control of pressure and efficiency over reasonably wide limits and with a constant speed motor. A rather novel type of control was introduced in the State Line Station on variable speed electrical driven auxiliaries, in which the motor has both a rotating stator and rotor, with a constant induction relative speed between the two sections, and the speed of the rotor controlled by variation in the load on the stator.

The higher pressure installations in the 1200 lb. class have come up to full expectations and during the year there has been sufficient experience to develop a trend to this pressure in projected new stations. Not only has the economy with the higher pressures been fully realized, but the cost of the installation with the higher pressures has shown a downward trend.

Performance of the mercury vapor power plant equipment installed in the South Meadow Station at Hartford, Connecticut, has been exceedingly satisfactory and has shown conclusively that this development is now beyond the experimental stage. The heat rate indicates a saving in coal consumption approximating 25 per cent and it is claimed that this equipment can be added to the less efficient stations, bringing their performance up to a modern station, with an increased capital expenditure consistent with the extension of a high-pressure plant.

The supply of direct-current power for traction loads has been improved by the development brought about in mercury arc rectifiers. Several installations have been made during the past year, giving exceptionally fine performance, and rectifiers are now available in sizes of 3000 kilowatts for 600-volt direct-current service. It is of interest to note that in the plan of development for the rapid transit lines in New York territory, automatic rectifier stations are planned for supply along the routes of the transit lines in a manner very similar to the installation of transformers on a.c. networks and the "third" rails used as the grid.

INCREASE *in use of* SINGLE ELEMENT GENERATORS *shown by Survey*

PROGRESS IN THE FIELD of electric generation during the year has continued along lines evolved during the past two or three years and while there has been a general improvement in all branches of the art, there have been no radically new developments or changes in design and use. The art of designing and constructing electric generating equipment is becoming pretty well standardized and the manufacturers seem willing to undertake the construction of generators of almost any size that any buyer cares to specify. As may be recalled, in our last year's report it was stated that, by means of hydrogen cooling, generators of 222,222 kv-a. could be constructed. During the year, no operating company, apparently has seen the need for a machine of this size, for the largest machine under construction at the present time is the 166,666-kv-a. unit of State Line Station.

The largest single element generator in operation is the 160,000-kv-a., 1500-r.p.m., 25-cycle machine installed in the East River Station this year. The details of this unit were described briefly in our last year's report. This machine is only a little smaller in capacity than the 166,666-kv-a. State Line unit referred to, but the latter is an 1800-r.p.m. unit while the East River machine is a 1500-r.p.m. machine. The voltages also are different, the East River generator operating at 11,400 v. while the State Line machine is being built for 22,000 v.

ELECTRIC GENERATOR PRACTICE

STATION	MAIN GENERATING UNITS										HOUSE SUPPLY			
						EXCITATION			COOLING SYSTEM					
	CAPACITY KV-A.	NO. OF ELEMENTS	SPEED	VOLTAGE	VOLTAGE REGULATION	TYPE EXCITERS	CAPACITY	EMERGENCY EXCITATION	SOURCE OF COOLING WATER	TEMP. AIR IN	TEMP. AIR OUT	METHOD USED	CAPACITY	ALTERNATIVE METHOD	VOLTAGE
JAMES H. REED	1-75,000	1	1800	11,600 V.	AUTOMATIC	SHAFT	200 KW.	450 KW. TURBO-GEN.	OHIO RIVER			MAIN GENERATOR THROUGH TRANSFORMER	3-2000 KV-A TRANS.	FROM 11 KV. BUS THROUGH 3-2000 KV-A. TRANS.	2300 V. 440 V.
BELLE ISLE	1-43,750	1	1800	13,800 V.	MANUAL	SHAFT	150 KW.	TURBO-GEN.	BELLE ISLE LAKE			FROM BUS THRU TRANS.	4-4000 KV-A TRANS.	DUPLICATE TRANS. BANKS	2300 V. 440 V.
RIO GRANDE	1-31,250	1	1800	13,800 V.	AUTOMATIC	SHAFT	135 KW.	DUAL DRIVE EXCITER	RIO GRANDE RIVER	157° F.	104° F.	MAIN BUS THRU TRANS.	1-2500 KV-A TRANS.	2500 KV-A. HOUSE GENERATOR 100% RELAY FOR 2500 KV-A. TRANS. ONE TRANS. 100% SPARE.	2300 V.
	1-23,500	1	1800	13,800 V.	AUTOMATIC	SHAFT	125 KW.	M.G. SET					2-300 KV-A TRANS.		460 V.
SHUFFLETON	2-43,750	1 EACH	1800	13,800 V.	AUTOMATIC	SHAFT	190 KW. 200 KW.	DUAL DRIVE EXCITER M.G. SET	LAKE WASHINGTON	136° F.	95° F.	UNIT BUSES FROM MAIN GENS. THRU TRANS. 2300 V. UNIT BUSES THRU TRANS.	1-4500 KV-A 1-3000 KV-A 2-600 KV-A TRANS.	EMERG. GEN. 3125 KV-A-2300 V. EMERG. 460 V. BUS FROM EMERG. 2300 V. BUS THRU 1-600 KV-A. TRANS.	2300 V. 460 V.
LOUISIANA	3-18,750	1 EACH	3,600	13,800	AUTOMATIC	SHAFT	90 KW.	TURBINE DRIVEN EXCITER	BOILER FEED SUPPLY	150° F.	104° F.	MAIN BUS THRU TRANS.	3-1500 KV-A TRANS.	ONE TRANS. 100% SPARE	460 V.
ATKINSON	1-66667	1	1800	13800 V	AUTOMATIC	SHAFT	200 KW.	200 KW. M.G. SET	CHATTAHOOCHEE RIVER			TAP FROM MAIN TRANS. & GEN. 13-8 KV. BUS	2-4000 KV-A 3 ϕ TRANS.	FROM 19 KV. SYSTEM FOR PLANT SERVICE WHEN NOT GENERATING CAPACITY 600 KV-A	2200 V. 550 V. 500 KV-A. CAPACITY AT 550 V.*
GREAT WESTERN	1-43,750	1	1800	11 500	AUTOMATIC	1 MOTOR DRIVEN 1 MOTOR & TURBINE DRIVEN	200 KW. 200 KW		SAN FRANCISCO BAY	145° F	104° F	FROM MAIN BUS TO TRANS. OR HOUSE GEN.	3-833 KV-A. 3-100 KV-A		2300 V. 440 V.
DEEPWATER	1-43,750 L.R.	1	1800	12000	AUTOMATIC	SHAFT	175 KW.	M.G. SET 250 KW.	SPRAY POND & WELLS FOR H.P. CONDENSATE MAIN SOURCE, SPRAY POND AUX. LOW PRESSURE ONLY	145° F	104° F	AUX. TRANS.	2500 KV-A	HOUSE GEN.	2300 V. 230 V.
	1-15,000 H.P.	1	3600	12 000	AUTOMATIC	SHAFT	65 KW.			144° F	104° F				
DALLAS	1-31 250	1	1800	13 800 V.	AUTOMATIC	SHAFT	145 KW.	M.G. SET	CONDENSATE AND SPRAY POND	154° F.	111° F.	MAIN GEN. THROUGH TRANS. BEFORE CIR. BREAKER	1500 KV-A	HOUSE TRANS. FROM 13 KV. MAIN BUS 1500 KV-A. CAPACITY	13800/440
DEVILS RIVER	2-9,375	1	3,600	13,800 V.	AUTOMATIC	SHAFT	45 KW.	M.G. SET	DEVILS RIVER	120° F.	98° F.	MAIN GEN. THROUGH TRANSFORMER	2-750 KV-A. 3 ϕ	FROM HIGH TENSION BUS THROUGH 1-750 KVA 3 ϕ TRANS.	440 V.
CONCEPCION ROAD	1-8,000	1	3600	13,600 V.	AUTOMATIC	SEPARATE	125 KW. 150 KW.	M.G. SET † TURBINE DR " "	SAN ANTONIO RIVER IN COMB. WITH SPRAY POND			FROM MAIN BUS THROUGH STEP DOWN TRANS.	2 BANKS OF 2000 KW. EACH	NONE	2300 V
	1-15,625	1	1800	13,200 V.	AUTOMATIC	SEPARATE	2-75 KW.								220 V.
SOUTH AMBOY	2-31,250	2	3600 H.P. 1800 L.R.	13 200 V. 13 200 V.		SHAFT	190 KW.	2 M G SETS 190 KW. EA	RARITAN BAY			MAIN BUS THROUGH TRANS.	3-833 KV-A		440 V.
WALDORF	1-1500 KW. GEARED D.C.	1	3540/514	250 V.	AUTOMATIC							NO TRANS.			
	1-3,750	1	3,600	480 V.	AUTOMATIC	SHAFT	25 KW.	NONE							
ATWATER KENT	1-1500	1	3,600	2300 V.		SHAFT		NONE	CITY WATER			DIRECT FROM MAIN BUS ON THRU TRANS.		CITY SERVICE CO	2300 V. 440 V
PROCTER & GAMBLE	2-2500	1	3600	480 V.	AUTOMATIC	SHAFT	15 KW.	DUPLICATE UNITS	OUTSIDE AIR THRU FILTERS			FROM MAIN GENERATOR		NONE	480 V.
	1-250	1	3600	480 V.	AUTOMATIC	SHAFT	5 KW.								
AMERICAN ENKA	2-2200 KW.		3600	550 V.	AUTOMATIC	SHAFT	13 KW.	M.G. SET	STORAGE RESERVOIR & CREEK			NO TRANSFORMERS			
CALUMET & ARIZONA	1-3750		3600	2400 V.	AUTOMATIC	SHAFT	25 KW.	M.G. SET	WELL WATER	159° F.	104° F.	FROM MAIN BUS THRU TRANS.	3-75 KVA.	NONE	2300 V. 440 V.
WILLIAM WILHEIM	2-300 KW. GEARED	1	6000/900	240 V.	AUTOMATIC	SHAFT	5.5 KW.	NONE	NATURAL VENTILATION			MAIN GENERATOR			220 V.
PT. BREEZE	NO GENERATING EQUIPMENT INSTALLED AT PRESENT											TRANS SUPPLIED BY PREFERRED & EMERG. FOR FROM 2 SEPARATE BUS SECTIONS	3-250 KV-A	3-500 KV-A. BANK & 1-500 KVA SPARE FOR EITHER BANK	440 V.
BUREAU OF STANDARDS	1-750 KW.	1	3600	2300 V.	AUTOMATIC	SEPARATE	12 KW.	BATTERIES	WASHINGTON CITY WATER			FROM MAIN BUS THRU TRANS.	200 KV-A.	NONE	220 V.
PROXIMITY	1-3225	1	3600	600 V.	AUTOMATIC	SHAFT	20 KW.	1 M.G. SET 1 ENG. DRIVEN SET	STORAGE LAKE	108° F	80° F	NO TRANSFORMERS			600 V.
	2-4250	1	3600	600 V.	AUTOMATIC	SHAFT	32 KW.								
UNIVERSITY OF NEBRASKA	2-1250 KW.	1	3600	2300 V	AUTOMATIC	SHAFT	16 KW.	NONE	COOLING TOWER AND POND			TRANS. FROM MAIN BUS	3-150 KV-A. 1-50 KV-A.		220 V. 110 V.
AMERICAN SALPA	2-625	1	3600	480 V.	AUTOMATIC	SHAFT	10 KW.	M.G. SET	DEEP WELLS			FROM MAIN BUS	250 KV-A	50 KW, OUTSIDE PWR	480 V.
	1-937	1	3600	480 V.			7.5 KW.	16 KW.							
CHAMPION COATED PAPER	1-20,000 KW. H.P. 9375 I.P. 9375 L.P. 875	3	3600 3600 1800	440 V.	AUTOMATIC	SHAFT SHAFT SEPARATE	40 KW. 40 KW 75 KW	TURBINE DRIVEN EXCITER	B.F. MAKE-UP WELL WATER						
TITANIUM PIGMENT	2-1250	1	3600	480 V.	AUTOMATIC	SHAFT	15 KW.	TURBINE DR. EXCITER				NO TRANSFORMER — DISTRIBUTION AT GENERATOR VOLTAGE			

These are the largest single element machines. In the field of compound units, the 235,000-kv-a. three-shaft generator placed in service at State Line during the year holds the record. Since the separate generators on a unit of this type are all considerably smaller than the 160,000 and 166,000-kv-a. single shaft machines, their construction and design is not as difficult as the single shaft units.

Perhaps the most interesting development in generator design from a mechanical standpoint at least, is the so-called vertical compound (also referred to as steeple compound) units installed at Station A in San Francisco and at the South Amboy Station. A unit of this type, the largest of the three, in fact, also is installed at the Ford Motor Co. These machines have been developed to reduce the amount of floor space occupied. The Ford Motor Co. unit consists of two generators, each running at 1800 r.p.m. with a total capacity of 124,911 kv-a. The two 50,000-kv-a. units of this type

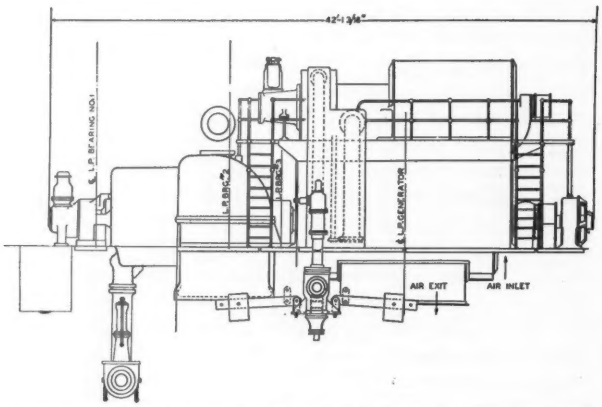


FIG. 1. GENERAL ELEVATION OF VERTICAL COMPOUND TURBO-GENERATOR AT SOUTH AMBOY

installed at Station A in San Francisco were referred to in our last year's report. This year two similar units were furnished to the Jersey Central Power & Light Co.[1] by the General Electric Co., for the South Amboy Station. These units as shown in the tabulation are rated at 31,250-kv-a. These machines consist of a high-pressure element rated at 5770 kv-a. mounted on top of a low-pressure element rated at 19,230 kw. The high-pressure element operates at 3600 r.p.m. and the low-pressure at 1800 r.p.m.

Among other large generators now under construction is a 115,000-kw., 18,000-v., 1800-r.p.m. single shaft generator for the Waukegan Station of the Public Service Co. of Northern Illinois. The rotor is a single forging and is one of the largest ever undertaken; rough turned, the weight is 240,000 lb. On these extremely large long generators, external motor-driven fans are being used so as to keep the span between the bearings as short as possible.

Of particular interest as regards the use of high speed, high capacity units, are the three generators at the Louisiana Steel Products Co. shown in the tabulation. These, it will be noted, are 3600-r.p.m. units and, rated at 18,750 kv-a., are the largest machines of this speed thus far made by the Westinghouse Electric & Mfg. Co.

In the list of plants considered in the accompanying tabulation, the largest generator installed this year was the 75,000-kv-a. machine at the Reed Station. This is an 1800-r.p.m., 60-cycle machine, wound for 11,600 v. provided with quick response excitation. From this unit as the largest, the machines vary in size all the way down to 9375 kv-a. in the central station group and to 250 kv-a. in the industrial group. Of course, in the industrial plant group, size or capacity has no fundamental significance, since generators are selected in accordance with the plant requirements. In the central station group, however, both the 43,750-kv-a. size and the 31,250-kv-a. size seem to be most popular.

A significant trend in electric generator practice is the use of single element generators. Last year, out of 13 central stations with 20 generators, eight of the units installed were two or three element units. This year, with a total of 12 central stations and 18 generators, only three are two element units. This does not necessarily indicate that the use of compound turbo-generators is diminishing, for in many cases a single element generator is driven by a tandem compound turbine. The simplicity of the tandem compound turbine with the single element generator makes its increased use desirable.

Speeds are approximately the same as they have been for the past few years, 1800 r.p.m. being standard for machines over around 15,000 or 18,000 kv-a. and 3600 r.p.m. for machines of lower capacity. Sixty-cycle units in industrial plants invariably run at 3600 r.p.m. The one exception listed in the tabulation, the 875 kv-a., 1800-r.p.m. unit at the Champion Contest Paper Co., happens to be an old unit which was adapted for use in a compound unit in the new plant. The 60-cycle frequency, of course, also is standard.

While the use of higher voltages with extremely large units has proved efficient, for machines below, say, 100,000 kv-a., the range of voltages between 11,000 and 14,000 still seems to be standard. As may be noted, the most popular voltage, or perhaps the most used voltage, is 13,800 v. In industrial plant generators, 2300 v. and 440 or 480 are most prevalent.

Another fact disclosed by a study of the plants in this year's survey is the almost universal use of automatic voltage regulation in preference to manual voltage control. Whether this has any fundamental significance or whether it is due merely to the character of the plants considered is not quite clear. It has been the general practice to use automatic voltage regulation in plants whose output was delivered largely over long transmission lines to distant load centers, while in the case of stations situated close to the load centers and where each feeder leaving the station was provided with an automatic voltage regulator, automatic regulation of generator voltage usually was dispensed with. Thus, large plants serving large metropolitan areas and located close to these areas usually have manual voltage control but stations located remote from the load centers had automatic regulators. Since the majority of the

[1] See Power Plant Engineering, p. 789, July 15, 1930.

central stations listed here come under the latter classification, the general use of automatic regulation probably denotes no departure from previous practice.

In exciter practice, the use of the shaft driven exciter is practically universal. The amount of exciter capacity in per cent of generator rating varies considerably, ranging from 0.267 per cent in the case of 75,000-kv-a. unit at Reed Station to 0.96 per cent for the new 15,625-kv-a. unit at Concepcion Road. Exciter capacity for small industrial plant generators in some cases is as high as 5 per cent, although the average is around 1 per cent. An attempt was made to plot a curve, showing the average per cent of exciter capacity for various generator capacity. This is shown in Fig. 2 but it is evident that with the points varying as widely as they do, the curve is only a general approximation.

Emergency excitation systems vary, some providing only motor-generator sets, others only turbine-driven emergency exciter units and still others, both.

The use of the sub-exciter is growing more prevalent, particularly in connection with extremely large generators, although this is not borne out by the information contained in the table. These sub-exciters are mounted on the same shaft with the main exciter, their purpose being to generate the field current for the main exciter. The advantages of the sub-excited are lower losses, greater stability and quick response.

Where it is necessary to obtain low excitation voltage from exciters feeding a.c. generators which may be required to supply charging current to long transmission lines, differential shunt fields have been employed on the exciters. These fields are about 10 per cent as heavy as the main shunt fields and are separately excited which permits the exciter to operate below its normal residual voltage value. This is especially necessary where voltage regulators are used, as the operation of the regulator depends upon its swinging voltage beyond the average value which is applied to the collector rings of the a.c. generator. By the use of the differential shunt fields, the main rheostat can be entirely eliminated even when the excitation required is below that of the residual of the exciter.

In some applications, particularly with synchronous condensers, it is necessary to provide excitation voltage down to zero volts. The General Electric Co. obtains this condition by providing a Wheatstone Bridge arrangement in the rheostat of the separately excited main field. With this arrangement, voltages down to zero and even in the reverse direction can be obtained without resorting to special field windings on the main exciter.

Ordinary a.c. generators when used with quick response excitation require an exciter voltage change of the order of 400 to 600 v. per second. This lower value of voltage change can be obtained with exciters without the use of laminated yokes.

In a quick response excitation system where voltage variation from the exciter is greater than 750 to 1000 v. per sec., eddy-currents in solid frames and in thick laminations in pole pieces materially retard the rate of change in voltage. To overcome this difficulty, the Westinghouse Co. has designed the exciter yoke of laminations held together by insulated end plates and the pole pieces are made of thin laminations held together by insulated rivets. This construction permits speeds of response of 3000 to 4000 v. per second. On one synchronous condenser installation made by the General Electric Co., the rate of rise on the main exciter was in excess of 7000 v. per second.

Generator cooling systems, with the exception of one or two small units in industrial plants which use natural ventilation, are all of the closed type, using either raw water, condensate or even water to be used for boiler feed in the cooler. The exit temperature of the air from the cooling systems is usually maintained somewhere around 100 deg. F.; a temperature of 104 deg. F. seems to be very popular.

System of House Supply

For the normal station power supply, the use of the house generator seems to be decreasing although it is provided for standby or emergency source in case the normal source fails. In nearly all cases, the power for auxiliary equipment is supplied from the main generators through step-down transformers. This practice of obtaining the auxiliary power from the main generators rather than from a separate house generator, is not only more economical since the efficiency of the main turbines (notwithstanding transformer losses) is higher than the house turbine, but with the general adoption of stage feedwater heating, the arrangement lends itself better to obtaining heat balance.

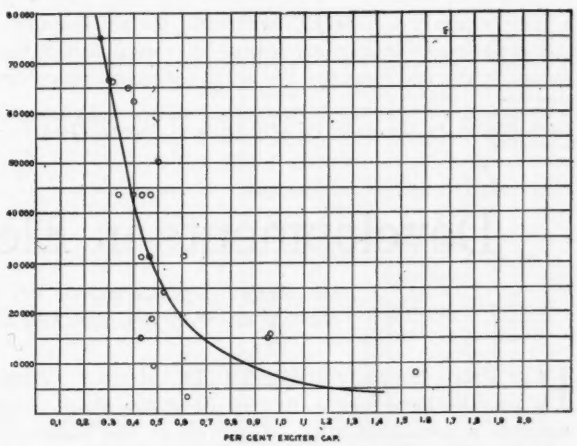


FIG. 2. CURVE SHOWING RELATION BETWEEN EXCITER AND GENERATOR CAPACITY

For the alternative house supply as intimated above, the house turbo-generator is used by a considerable number of stations because for emergency purposes the questions of economy or heat balance are secondary considerations. Where a station is connected by transmission lines to another station or other sources of power supply, the emergency station power supply may be derived from these outside sources through transformers.

Another reason for the practice of operating the auxiliaries from the main generators through transformers, is the increasing use of sectionalized buses. Sectionalizing the buses limits any disturbance to a small section of the station. In many instances, a unit system has been adopted in which only the auxiliaries for a single unit are fed from any one bus section. In

this way the failure of such a bus section takes out the auxiliaries for one unit only.

In other instances, the idea has been extended still further to furnish a diversity of supply even among the auxiliaries of each individual unit, such as by supplying half the auxiliaries of a certain generator from one bus section while the other half is supplied from a bus section associated with another generator. With such an arrangement, the loss of a complete bus section would take out half the auxiliaries for each of two units—keeping both units in operation at a somewhat reduced capacity.

Thus, the diversity is actually carried from the source of supply to the load. For instance, as is the case at Reed Station, cooling water is supplied to the main condenser by two pumps driven by two motors fed from separate bus sections which in turn are fed from two different main generators.

In regard to the use of sectionalizing breakers in the 2300-v. auxiliary bus system, the installation at Reed Station is of interest.[2] This breaker has been placed in a room entirely by itself. According to the designers, sad experiences in various plants have emphasized the necessity for isolating the bus sectionalizing breaker in this manner. Since the purpose of this breaker is to isolate the bus sections, it is of great importance that this breaker itself be isolated from damage due to failure of adjacent equipment, otherwise its very purpose will be defeated. So, at Reed Station, this breaker has been located in a room entirely by itself.

Voltages used for anxiliaries are either 2300 or 440, both voltages being used in many of the stations. In all of the larger plants, it is common practice to use 2300 v., 3-phase power for all of the larger motors which in some stations include those of 100 hp. and in others as small as 25 hp. For the smaller motors, 550, 440 and 220 are used and for lighting 110 or 220 v. Some plants use but one of the above voltages, others use two or more. Some plants combine the lighting and power load on a 220—110-v. or 120—208-v. system. In general, 3-phase current is used for motors of lower voltage as well as for the 2300-v. motors, although in certain plants 2-phase current is employed.

None of the stations listed use direct current for auxiliaries but in some cases the use of direct current has proved successful. The chief claim for the advantage of direct current lies in the economies derived from the adjustable speed d.c. motor. In some cases not the entire auxiliary supply is direct current but only certain auxiliaries—those requiring adjustable speed motors.

[2]See article Power Supply System for Station Auxiliaries at Reed Station in the June 15, 1930 issue of Power Plant Engineering.

Developments in Electric System Practice

IMPORTANT DEVELOPMENTS OF YEAR INCLUDE, DE-ION PRINCIPLE, MINIATURE SWITCHBOARDS AND NEW LIGHTNING ARRESTER MATERIAL

RECENT DEVELOPMENTS IN electric system practice have been mainly in directions which tends towards a deconcentration of energy at the points of generation and centers of distribution and in schemes which tend to divide the system into sections which will limit the possible short circuit currents in case of trouble. With the great increase in the generating capacity of our power systems, the amounts of power available during a fault are so enormous that it becomes extremely difficult to design protective equipment to cope with it. In the case of oil circuit breakers for instance, even though oil circuit breakers are available with rated interrupting capacities of a million and a half kv-a., these capacities often are below the possible fault currents on commercial systems. The problem, therefore, resolves itself into either improving the design of circuit breakers or reducing the value of the possible fault currents by subdivision of the distribution system or some equivalent scheme.

In our survey last year, mention was made of the synchronized at load system of the New York Edison Co. This was a step in this direction for, as pointed out by H. R. Woodrow[1] in another article in this issue, in such systems, the generating station bus is no longer the center of the system with the concentration of large blocks of power at this point.

Several schemes, differing from the synchronized at load system in details but having a similar object in view have been adopted by a number of the companies serving large cities. These systems were fully discussed in an article in Power Plant Engineering in June of this year[2] by A. H. Kehoe of the United Electric Light & Power Co. Few of the stations included in this present survey are of this particular character and as a consequence tendency in electric system practice is not evident from the accompanying tabulations. It will be noted, however, that wherever possible there is a tendency to do away with the low-voltage main generator bus. Nearly all those stations, delivering power to long transmission lines, feed these lines either directly from the generator through transformers or from a high tension outdoor bus.

From the single line diagrams of the various systems shown in the "Electric System Data" table, it is evident that arrangements differ considerably in detail although as regards principle, most of them can be arranged into two or three groups. Where no low-voltage generator bus is provided, most arrangements include some sort of synchronizing bus.

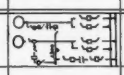
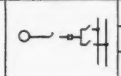
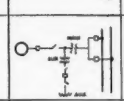
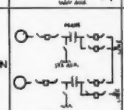
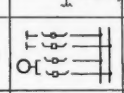
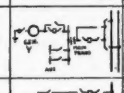
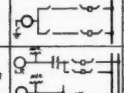
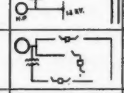
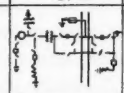
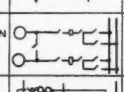
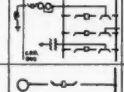
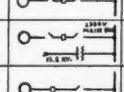
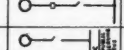
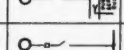
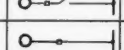
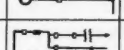
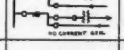
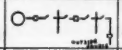
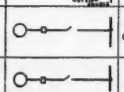
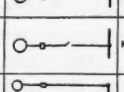
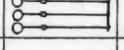
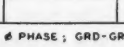
Where low-voltage generator buses are employed nearly all stations use the isolated phase arrangement and this usually in the vertical form. The horizontal isolated scheme brought out several years ago seems not to have endured as some stations which used this scheme in the bus layouts for their initial installations, in subsequent additions went back to the vertical isolated phase system.

The oil circuit breakers in use with such bus systems

[1]See p. 1415.

[2]June 15 issue, p. 688.

ELECTRIC SYSTEM DATA

STATION	BUS AND SWITCHING SYSTEM: SINGLE LINE DIAGRAM GENERATOR TO BUS	BUS AND SWITCHING SYSTEM: TYPE & VOLTAGE OF OIL CIRCUIT BREAKER	BUS SYSTEM: TYPE	BUS SYSTEM: VOLTAGE	PROTECTIVE FEATURES: REACTORS	PROTECTIVE FEATURES: RELAYS	PROTECTIVE FEATURES: GROUND	PROTECTIVE FEATURES: TYPE LIGHTNING ARRESTOR	TRANSFORMERS: TYPE	TRANSFORMERS: PURPOSE	TRANSFORMERS: CAPACITY	TRANSFORMERS: WINDING CONNECTION	TRANSFORMERS: POTENTIAL CHANGE
JAMES H REED		15 KV. INDOOR MOTOR OPER.	VERT. ISOLAT. PHASE MAIN AUX. & SYN	11 KV.	11 KV. IN ALL FEEDERS	GEN. DIFF. & TRANS. DIFF. PROTECTION	GEN. NOT GRD. TRANS. GRD. THRU TRANS. & 10 ω RESISTOR	NONE – ALL FEEDERS ARE CUBICAL	O.I.S.C.	MAIN POWER	6-5000 KVA 6-5000 6-8333	YY ΔY	11/22 KV. 11/66 KV.
BELLE ISLE		15 KV OUTDOOR SOLENOID OPER. 66 KV OUTDOOR SOLENOID OPER. 33 KV OUTDOOR SOLENOID OPER.	DOUBLE BUS DOUBLE BUS DOUBLE BUS	13.8 KV. 66 KV. 33 KV.	FEEDER NONE TRANS.	GENERATOR – DIFF. TRANSFORMER – DIFF.	1000 AMP. GRD. TRANS. TRANSFORMER NEUTRAL TRANSFORMER NEUTRAL	3 PHASE 13.8 KV. POROUS BLOCK 3 PHASE 66 KV AUTOVALVE 3 PHASE 33 KV AUTOVALVE	O.I.S.C.	MAIN POWER	2-3 PHASE 30,000 KV-A	Δ Y GROUNDED NEUTRAL	13.8/33/66 KV.
RIO GRANDE		15 KV. INDOOR SOLENOID OPER. 75 KV OUTDOOR SOLENOID OPER.	NO GEN. BUS	13.8 KV.	NONE	GENERATOR DIFF. TRANSFORMER DIFF.	NEUTRAL GRD. 4 ω RESISTOR NEUTRAL O.C.B. FOR EA. GEN.	3 PHASE OXIDE FILM 75 KV UNGRD. NEUTRAL	O.I.S.C. O.I.S.C.	MAIN POWER STATION POWER	1 BANK OF 3-10,000 KV-A 1-3 PHASE 2500 KV-A. 2-3 PHASE 300 KV-A. EA.	Δ Y Δ Δ Δ Δ	13.8/66 KV. 13.8/2.3 KV. 2300/460 V.
SHUFFLETON		15 KV. INDOOR SOLENOID OPER. 75 KV. OUTDOOR MOTOR OPER.	ONLY A SYNCHRON. BUS	55 KV.	NONE	GENERATOR DIFF. TRANSFORMER DIFF.	GEN. NEUTRAL 4 ω RESISTOR O.C.B. FOR EA. GENERATOR	3 PHASE AUTOVALVE 55 KV.	O.I.S.C. O.I.S.C.	MAIN POWER STATION POWER	2-BANKS OF 3-16667 KV-A 1 BANK OF 3-1500 KV-A 1 BANK OF 2-1500 KV-A 3 BANKS OF 3-200 KV-A	Δ Y Δ Δ Δ Δ OPEN DELTA Δ Δ	13.8/55 KV. 13800/2300 V. 2300/460 V.
LOUISIANA		15 KV. INDOOR CELL MOUNTED SOLENOID OPER.	DOUBLE	13.8 KV.	NONE	GENERATOR RATIO DIFFERENTIAL	4 ω NEUTRAL GRD. RESISTOR O.C.B. FOR EACH GENERATOR	3 SINGLE ϕ POROUS BLOCK FOR EA. 66 KV. FEEDERS	O.I.S.C. O.I.S.C.	66 KV. FDRS. STATION POWER	3-10000 KV-A 2-1500 KV-A. 3 PHASE	Δ Y GRD. NEUTRAL Δ Δ	13.8/66 KV. 13.8/0.48 KV.
ATKINSON		110 KV. OUTDOOR MOTOR OPER.	NO GEN. BUS	13.8 KV.	NONE	GEN. SPLIT PHASE DIFF. & OVERLOAD TRANS – OVERLOAD & OVERALL DIFF	NEUT. NORMALLY GRD. THROUGH S.P.S.T. O.C.B.	3 ϕ OXIDE FILM 97 – 121 KV.	O.I.W.C. O.I.W.C.	MAIN POWER STATION POWER	2-28333 KV-A 2-4000 KV-A 3 ϕ	Δ Y NORM. GRD. Δ Y NEUT. GRD.	132/66.45/115 KV. 13.8/2.3 KV.
GREAT WESTERN		37 KV OUTDOOR MOTOR OPER	DOUBLE BUS OUTDOOR	11.5 KV.	THREE	GENERATOR DIFF. GENERATOR NEUTRAL	NEUTRAL GRD. THROUGH DISCONNECTS	NONE	——	——	——	——	——
DEEPWATER		73 KV. OUTDOOR SOLENOID OPER.	NO GEN. BUS	12 KV.	NONE	GEN. & TRANS. DIFF. GENERATOR NEUTRAL O. CURRENT RELAY OVERALL DIFF. RELAY	NEUTRAL GRD. 2 ω RESISTOR SW. NORMALLY CLOSED	3 ϕ OXIDE FILM 50 – 73 KV.	O.I.S.C.	STATION PWR.	1-20,000 KV-A 1-25,000 KV-A.	Δ Y	12/33/66 KV.
DALLAS		2000 A. CAP 13 KV.	INDOOR	13.8 KV.	IN MAIN BUS	GEN. & TRANS. DIFF. OVERLOAD ALL FEEDERS	GROUNDED NEUTRAL	60 KV. OXIDE FILM	O.I.S.C.	INTERCONN.	3-10,000 KV-A	3 WINDING Y Y DELTA TERTIARY	16/60 KV.
DEVILS RIVER		75 KV. OUTDOOR SPRING OPER.	NO GEN. BUS	13.8 KV.	NONE	GENERATOR DIFF. SERVICE TRANS. DIFF.	NEUTRAL GRD. SOLID. OIL SW. & DISCONNECTS NORMALLY CLOSED	3 ϕ OXIDE FILM 50 – 73 KV.	O.I.S.C. O.I.S.C. O.I.S.C.	MAIN POWER STATION POWER EMERGENCY HSE SERVICE	3-3333 KV-A EACH GEN 1-3 ϕ 750 KV-A EACH GEN. 1-3 ϕ 750 KV-A	Δ Y GRD. NEUT. Δ Y Y Δ	13.8/66 KV. 13.8/0.44 KV. 66/0.44 KV.
CONCEPCION ROAD		15 KV. OUTDOOR SOLENOID OPER.	NO GEN. BUS	13.6 KV.	NONE	OVERALL DIFF. TRANS. ON HOUSE BANKS. DO. O'LOAD RELAYS ON LOOPS & RADIAL FEEDERS	NEUTRAL GRD. 10 ω RESISTOR DISCONNECT SW. NORM. CLOSED	ELECTROLYTIC	O.I.S.C.	STATION POWER	2 BANKS OF 2000 KVA. EA.	Δ Δ	13.2/2.3 KV.
SOUTH AMBOY		15 KV. MOTOR INDOOR OPER. 37 KV. OUTDOOR 73 KV OUTDOOR		13.2 KV.	IN NEUTRAL GROUND 81.6 % 13.8 KV. 1300 A.		NEUTRAL GRD THROUGH REACTOR	POROUS BLOCK 33-66 KV.	O.I.S.C.	MAIN POWER	3-10,000 KV-A 1 ϕ	Δ Y Δ	13.8/66-132/33 KV.
WALDORF			GROUP ϕ BUS	480 V.	NONE	——	——	——	——	—— NO TRANSFORMER USED ——			
ATWATER KENT		2300 V. O.C.B.	GROUP PHASE	2300 V.	NONE	——	——	——	O.I.S.C.	INTERCONN. WITH UTILITY			13.2/2.3 KV.
PROCTER & GAMBLE		600 V. 3000 A. SOLENOID OPER.	SINGLE GROUP PHASE	480 V.	NONE	NONE ON GENERATOR OVERLOAD ON PLANT FEEDERS	SYSTEM NOT GROUNDED	NONE	—— NO TRANSFORMERS USED ——				
AMERICAN ENKA		600 V.	GROUP ϕ	550 V.	NONE	OVER CURRENT-TIME	NOT GRD.	NONE	—— NO TRANSFORMERS USED ——				
CALUMET & ARIZONA		75 KV. INDOOR SOLENOID OPER.	SINGLE GROUP ϕ	23 KV	NONE	GENERATOR DIFF.	NOT GRD.	NONE	O.I.S.C.	STATION POWER	3-75 KV-A	Δ Δ	2300/440 V
WILLIAM WILHEIM		15 KV. 1200 A. 3 POLE	SINGLE GROUP ϕ	240 V.	NONE	GENERATOR DIFF. FEEDERS I.T.L.	NONE	NONE	O.I.S.C. AUTO. TRANS	FEEDERS	2 BANKS OF 2-100 KVA. EA.	3 ϕ 3 W. TO 2 ϕ 4 W. SCOTT	NONE
PT. BREEZE		15 KV. INDOOR STEEL CLAD SOLENOID OPER.	RADIAL	13.2 KV.	THREE OIL COOLED	OVER CURRENT ON INCOMING LINES	TRANS. Y-CONNECTION NEUTRAL SOLIDLY GRD.	NONE	O.I.S.C.	STATION POWER	2B-3-833 KVA 2B-3-1000 " 1B-3-500 " 2B-3-250 "	Δ Y	13.2 0.44 KV.
BUREAU OF STANDARDS		7500 V. O.C.B. SOLENOID OPER.	GROUP PHASE	23 KV.	NONE	OVERLOAD. TIME LIMIT REVERSE POWER ON OUTSIDE SOURCE	NOT GRD.	3 ϕ OXIDE FILM	O.I.S.C.	INTERCONN. WITH OUTSIDE SOURCE	3-250 KV-A	Δ Δ	13.2/2.3 KV.
PROXIMITY		8 KV. SOLENOID OPERATED O.C.B.	GROUP PHASE	8 KV.	NONE	C.O. OVERLOAD & UNBALANCED CURRENT RELAYS	NEUTRAL GRD.	OXIDE FILM	O.I.S.C.	MAIN POWER	1B-1000 KVA 1 – 750 " 1 – 500 "	GRD. NEUTRAL	
UNIVERSITY OF NEBRASKA		O.C.B. 7.5 KV.	GROUP PHASE	2.3 KV.	NONE	OVERLOAD OF FDRS.	NOT GRD.	NONE	O.I.S.C	STATION POWER & LIGHTING	3-150 KV-A 1-50 "	Δ Δ	2.3/0.22 KV 2.3/0.11 "
AMERICAN SALPA		MANUAL OPER. O.C.B.	GROUP PHASE	480 V.	NONE	GENERATOR DIFF OVERCURRENT RELAY OVERALL DIFF. RELAY	NOT GRD.	NONE	O.I.S.C	LIGHTING	1-5 KV-A 1-10 " 1-15 KV-A 1-25 "	Y Y	
CHAMPION COATED PAPER			GROUP PHASE	440 V									
TITANIUM PIGMENT													

ω OHM, ϕ PHASE; GRD-GROUND OR GROUNDED; DIFF-DIFFERENTIAL

are usually of the separate pole tank type, with each pole mounted in a separate concrete or brick cell. Such breakers are operated from a remote control by motor or solenoid mechanisms.

In the circuit breaker field one of the important developments of the year was the presentation, by the Westinghouse Co. of the De-ion principle. This perhaps, was not so revolutionary as was the announcement of the oilless De-ion breaker, nevertheless it promises to be of great importance because the possibility of its application seems more immediate and more universal.

Miniature Switchboards

An extremely interesting development of the year, is the development of the miniature switchboard. With the growth of our electrical systems, switchboards have become so large that excessive space requirements are necessary and they are no longer easily under the control of the operators. With present day switchboards, to control an individual circuit or portion of a circuit or panel from 12 to 30 in. wide is necessary. It is true that this particular circuit may be handling more power than it was 10 years ago, but that is exactly the sore point. The advance has been in the circuit itself not in the switchboard.

As a consequence a development in miniature switchboard has been made, embracing and containing all the fundamental requirements of a control switchboard and yet with no greater space than 4 in. of panel width for complete control and supervision of one feeder. Instrument elements have been developed for a.c. or d.c. ammeters, voltmeters, wattmeters and kv-a. meters which can be mounted in a standard case having a front 4 in. wide by 4½ in. high and a body of approximately 3½ in. square. The advantages of this development are compactness, ease of operation, close supervision, ease of erection, good appearance and modernity.

The use of reactors is not prevalent except in the case of high capacity systems where they are used between bus sections and in the separate feeders.

For the protection of the main generators, the differential relay method of protection is used almost universally. This scheme is simple and effective under most conditions of trouble, and is flexible in its application. It may be applied to machines of any size, either star or delta-connected, provided both ends of each phase winding can be brought out and connected through current transformers. Sometimes as in the case of the Atkinson plant it is used in combination with the split conductor protective scheme. While this arrangement is more complicated and is not applicable to machines having only a single winding, it is possible to detect an open circuit or a short circuited turn with it. It protects against all internal faults, including phase to phase short circuits, grounds, short circuited turns of the machine winding and open circuits not involving all paths of the machine winding.

Grounding practice is fairly uniform, in most stations, the generator neutral is grounded through a resistor. In several cases, however, the resistor is not used and the neutral is grounded solidly through a circuit breaker or disconnect switch which under normal conditions is kept closed. In industrial plants the practice seems to be not to ground the generators.

In connection with grounding practice, the question of grounding transformer bank neutrals through different impedances has arisen recently due to the desire to limit system single-phase and two-phase short circuit currents. It was found that the use of resistance, only, may be undesirable on account of the high voltage at the neutral in limiting the short circuit current. The use of impedance, only, may result in high voltages within the transformers and at the neutral due to lightning transients which necessitates the transformer being fully insulated throughout. To correct this trouble, methods using parallel paths with the inductance, (these parallel paths being designed primarily to reduce the lightning transients at the neutral) have been studied and found to limit the transients within the transformer to values approximating those for solidly-grounded neutral which permit the grading of the transformer insulation.

Lightning arresters in use in most cases are of the porous block or oxide film type although in some cases the electrolytic type is installed. During the year both the Westinghouse and General Electric Co.s announced new developments in the lightning arrester field, the former bringing out a new Autovalve arrester and the latter, the Thyrite arrester. Both of these arresters make use of materials which have the desirable characteristic of behaving as insulators at low voltages and as conductors at high voltage.

The principle and characteristics of Thyrite[4] were described in detail in Power Plant Engineering in the early part of this year. The material, Thyrite, has properties that make it both an insulation and a conductor, that is it possesses the remarkable property of changing its resistance to the flow of electricity as the voltage is changed. This change is such that each time the applied voltage is doubled, the resistance decreases so that the current is increased more than 12 times. This means that if the voltage is increased 16 times, the current is increased 25,000 times. The values of such a material in lightning arrester design are readily apparent.

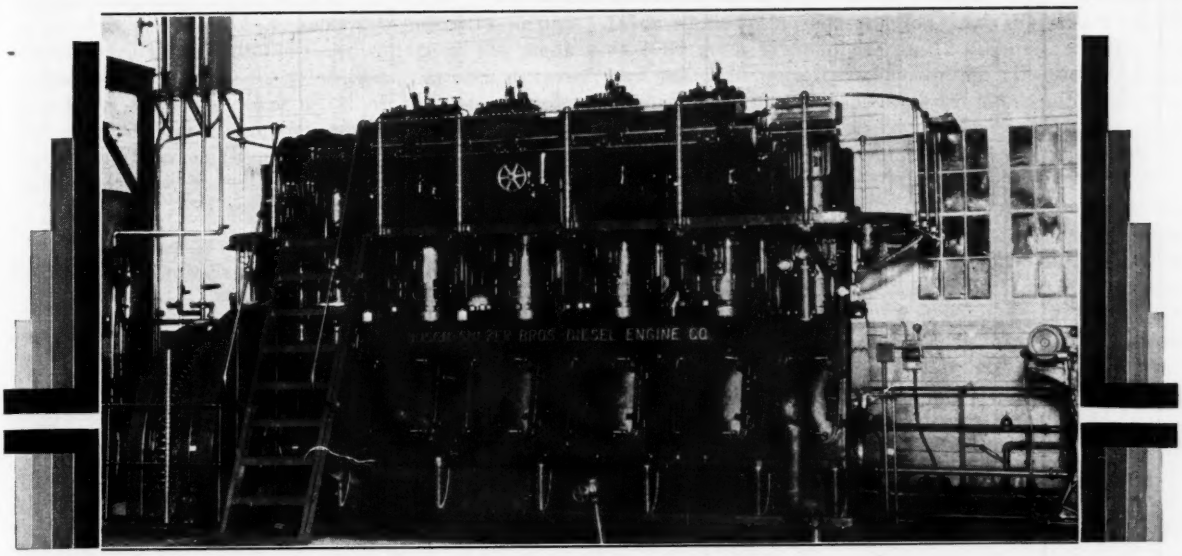
Transformers

Transformer development has continued in directions laid down several years ago and consists largely in further refinement of design and construction. The use of equipment for changing the ratio of transformers without interrupting the load has been extended and equipment for doing this has become largely standardized and manufactured on a quantity production basis.

As shown in the accompanying tabulation, the use of the oil insulated self-cooled transformer seems to be general practice. Only in one case, that of the Atkinson Station, are water-cooled transformers used.

Capacities vary widely, of course, according to the individual requirements of the station or system. Among the notable transformer installations of the year are four Westinghouse single-phase, 60-cycle units installed in the Roseland Switching Station of the Public Service Electric & Gas Co. Each transformer has four separate windings rated at, 30,000, 15,000, 15,000, and 20,000 kv-a. self-cooled. The design permits the addition of forced air cooling equipment to obtain 50 per cent higher ratings. On the basis of half the sum of these forced air-cooled ratings the units are equivalent to 60,000-kv-a., two-coil transformers.

[4] April 1, 1930 issue, p. 389.



Further Refinement Characterizes Diesel Power

REFINEMENT OF ENGINE CONSTRUCTION, INCREASE IN USE OF AUXILIARY EQUIPMENT AND IMPROVED PLANT MANAGEMENT INCREASE RELIABILITY OF DIESEL POWER

PRESENT DAY Diesel engine construction shows no radical departure from original designs. Simplification in appearance and sturdiness of construction continue to be trends. The box construction of cylinder units bolted together, for these reasons, appears to have gained in favor.

NO RADICAL DEPARTURE IN ENGINE DESIGN

After a period of 30 yr., since many of the European gas engines types were built in some modified form in this country, we find the Oechelhaüser-Junkers type of 2-cycle engine with opposed piston and triple crank construction for each cylinder, to be in building in this country for marine service.

SPECIAL ALLOY METALS NOW USED

Due to increasing use of high rotative and piston speeds and to desire for increased reliability, special metals, particularly for crankshafts, connecting rods, pins and bolts and including cylinders and piston rings, are increasingly employed. Use of chrome-nickel steel is now being made for crankshafts and this steel and chrome-molybdenum steel and other alloys, employed for other engine parts. The greater difficulty of manipulation of alloy steels is being overcome by more extensive use of grinding methods. Chromium plating has been used to prevent corrosion and gives promise of wider application on wearing surfaces such as piston rods, because of its hardness. Nitriding and use of stainless steels have been successful in resisting corrosion where fuels containing hydrogen sulphide were employed.

IMPROVED FABRICATION

More general care in workmanship, in which more or less precision methods of fabrication including the use of highly specialized machine tools, jigs and fixtures and increased use of precision grinding, have been employed, is in evidence and more general adoption of some form of forced lubrication, not only for the ordinary bearing surfaces but for cylinder lubrication.

Built-up crankshafts are preferred for large sizes by some builders who claim separate forgings permit of better working of the material but improved pressure forging methods now produce uniform conditions in large and irregular forgings. Main bearings are being constructed increasingly with removable bearing shells of steel casting lined with a high percentage tin—base babbit metal. Nickel or chrome-nickel cast iron, whose percentage of ingredients has been controlled carefully in an electric furnace, is being used increasingly for cylinders. Aluminum alloys are finding increased application for pistons and other reciprocating parts in high-speed engines, to reduce the inertia effect and vibration and to aid in heat conduction.

DIESEL PLANT REFINEMENTS

Refinements in Diesel plants have included the rather general use of air and oil filters of some kind. Of the latter, settling, cooling, screening and centrifuging, in many cases in combination, are adopted. Refinement of this kind has become standard equipment to such an extent that some engine builders now incorporate oil or air filters or both in their design of engine. Introduction of fuel filters and use of centrifuges for the removal of water and foreign matter is increasing.

Cooling water treatment has become so universal that many engine builders will not accept an order for equipment unless a test of the available water has been made and proper water treatment provided for, where it is needed. The closed system using distilled water is now employed in many large plants. Oil, as a cooling me-

DIESEL PLANT DATA

PLANT	LOCATION	KIND OF SERVICE	ANNUAL NET STATION OUTPUT KW HR	AVERAGE NET STATION OUTPUT KW DAILY	CORRESPONDING DAILY HOUSE LOAD	PEAK LOAD KW.	LOAD FACTOR PLANT ②	LOAD FACTOR MACH. ③	HP. OF UNITS	NO. CYLINDERS	CYCLE	FUEL INJECTION	CYLINDER AIR COMPRESSOR	FUEL BAUME' GRAVITY	FUEL B.T.U. PER GAL.	OIL CONSUMPTION KW. HR. PER GAL. FUEL	OIL CONSUMPTION KW. HR. PER GAL. LUBRICANT	TYPE OIL PURIFICATION FUEL	TYPE OIL PURIFICATION LUBRICANT	FUEL OIL STORAGE TYPE AND LOCATION	FUEL OIL STORAGE CAPACITY GALLONS	COOLING WATER METHOD	COOLING WATER TYPE SYSTEM	COOLING WATER TEMP. °F. IN	COOLING WATER TEMP. °F. OUT	COOLING WATER STORAGE CAP GAL	WATER TREATMENT TYPE	WATER TREATMENT CAP GAL. PER DAY	AIR FILTER TYPE	EXHAUST TEMP °F ④	EXHAUST TYPE COOLING	EXHAUST TYPE MUFFLER
CENTRAL STATIONS																																	
CENTRAL PWR. & LIGHT CO	UVALDE TEXAS	STAND-BY P. & L.	14,818,590	44,200	1703	2000	0.820	0.80	2-1125 2-500	8 4	4 4	SOLID AIR	PISTON	28-30	146,500	11.9	203.5	NONE	CENTRIF.	UNDER GROUND	2-20,000	TOWER	OPEN	80	105	30,000	ZEOLITE	45,000	MULTI CELLULAR	650	MANIFOLD	SOUND-WAVE FILTER
CONSOLIDATED PUBLIC UTILITIES	WESTMINSTER MD.	P & L.	2,034,830	———	—				F 1300 A 1-660	8	4	SOLID	PISTON		———	9.85			FILTER & SETTLING	TANKS ABOVE GROUND	2-50,000	NONE-WATER FROM MAIN			105	———	NONE-USE	CITY WATER	NONE	———	MANIFOLD & EXHAUST PIPE	POT
TUCSON GAS ELECTRIC L&P. CO	TUCSON ARIZONA	P & L.	23,652,870	65,350	4700	6650	0.41	0.34	F 7840 A 1-3,750	8	2	AIR	3 STAGE AIR	19+	149,500	12	1010	SETTLING & SCREENING	SETTLING & SCREENING	TANKS ABOVE GROUND	1-250,000 1-105,000	SPRAY POND	OPEN	100	138	40,000	ZEOLITE	80,000	AIR WASHER ON 2-3750	580	MANIFOLD	SOUND WAVE ON 2-3750
OTTER TAIL POWER CO.	APPLETON MINN.	P&L.	PLANT JUST STARTED						2-1760	8	2	AIR	3 STAGE COMP.	18-22	148,300	———	———	SETTLING SCREENING	SETTLING FILTER	BELOW GROUND	4-20,000	HEAT EXCHANGER	CLOSED	—	—	20000	NONE-USE	RAIN WATER	MULTI CELL	———	NONE	C.I. POT WITH CONCRETE PIT
OTTER TAIL POWER CO.	LANGDON N. D	P&L	ENGINE JUST INSTALLED						1-1760	8	2	AIR	3 STAGE COMP.	18-22	148,300	———	———	SETTLING SCREENING	SETTLING FILTER	UNDER GROUND	2-20,000	TOWER & CLOSED COILS	CLOSED	—	—	15 000	NONE-USE	RAIN WATER	MULTI CELL	———	NONE	C.I. POT WITH CONCRETE PIT
MUNICIPAL PLANTS																																	
MUNICIPAL ⑧	BROKEN BOW NEBRASKA	P&L.	750,000 E	2577	—	220	———	———	F 460 A 1-380	6	2	SOLID	PISTON	32-36	148,616	9.33	919.7	SCREENING	———	TANK ABOVE GROUND	1-10,000	⑧	———	50	110	20000	———	———	———	400	MANIFOLD	PIT & PIPE
MUNICIPAL	CHAPPELLE NEBRASKA	P&L	652,000	1850	—	185	———	———	F 300 1-375	5	4	SOLID	PISTON	34-38	———	11.25	2200	———	———	TANK ABOVE GROUND	1-12,000	NONE CITY WATER	OPEN	60	100	50000	———	———	MULTICELL	———	MANIFOLD	STEEL POTS
MUNICIPAL	FALLS CITY NEBRASKA	P. & L	2,249,280	———	—	—	———	———	F 1440 A 1000	6	2	SOLID	PISTON	———	———	———	———	STRAINERS	CENTRIF	———	———	SPRAY POND	———	—	—	———	———	———	———	———	MANIFOLD	PIT
MUNICIPAL	MENASHA WISCONSIN	P&L.	3,883,640	10 585	18	1080	0.334	0.433	F-2400 A-1-1200	6	4	AIR	PISTON	24-26	144,895	11.56	2328	SETTLING SCREENING	CENTRIF	TANKS ABOVE GROUND	1-30,000 2-10,000	NONE CITY WATER	OPEN	33 TO 82	125	———	———	———	AIR MAT	650	MANIFOLD	SOUND WAVE
MUNICIPAL	ROCKVILLE CENTER L.I. N.Y.	P&L	5,830,990	205			0.402	0.635	F-3330 A-1-1250	4	4	AIR		22+		10.56	1590		CENTRIF.	TANKS ABOVE GROUND	2-20,000	NONE WELL WATER	OPEN			———	———	———	———	———	WASTE HEAT BOILERS	SOUND WAVE
MUNICIPAL	WINTERSET IOWA	P&L	———	———	—	—	———	———	1-720	5	4	AIR	TRUNK PISTON	22-24	145,000	11	2000	HEATING SETTLING SCREENING	SETTLING SCREENING COOLING	STEEL TANKS ABOVE GROUND	2-12,000	TOWER	OPEN	80	110	6500	ZEOLITE FOR MAKEUP	———	ATMOSPHERIC INTAKE	700	WASTE HEAT BOILER	MUFFLER COMB. WITH WHB
INDUSTRIAL APPLICATIONS																																	
ATLANTIC WIRE CO.	BRANFORD CONN	P & L	1,047,480	3100		500	0.44	0.61	2-200	6	4	AIR	PISTON	28-32	143,400	10.9	660	SETTLING SCREENING	CENTRIF	TANKS ABOVE GROUND	2-10,000	CITY WATER	———	60	135	———	———	———	——— ⑦	600	MANIFOLD	CONCRETE POT & PIPE
CHRISTMAS COPPER CO.	CHRISTMAS ARIZONA	P & L	———	625	—	900	0.694	0.76	F-1350 ⑧ A-450		4	SOLID	PISTON	24	140,600	10.7	408	———	CENTRIF.	TANKS ABOVE GROUND	3-15,000	TOWER	OPEN	68 70	80 110	4200	ZEOLITE	4300	MULTICELL		MANIFOLD	POT
KNICKERBOCKER ICE CO	FAR ROCKAWAY N.Y.	ICE MFG.	13,034 TONS ICE	130 TONS ICE	—	—	0.871	0.65	1-400 1-300	8 2	4	SOLID	PISTON	28-32	135,939			SETTLING SCREENING	FILTER SETTLING	TANK ABOVE GROUND	1-10,000	WELL WATER	CLOSED	82	102					540 600	MANIFOLD	POT
KNICKERBOCKER ICE	LYNBROOK N.Y.	ICE MFG	11,813 TONS ICE	85 TONS ICE	—	—	0.576	0.768	1400 1-100 AUX 1-40 AUX.	6 1 1	4 4 4	SOLID	PISTON	28-32	135,939			SETTLING & SCREENING	FILTER & SETTLING	TANK ABOVE GROUND	1-5000	TOWER	OPEN	72	92					480	MANIFOLD	POT
VESTA BATTERY CO.	CHICAGO ILL.	P & L.	1,000,000 E			300		———	2-160 1-300	4 6	4	SOLID	PISTON	28-30	141,700	11.8	500	NONE	CENTRIF.	STEEL BELOW GROUND	1-10,000	TOWER	OPEN	70	110	15 000	———	———	———	350	MANIFOLD	C.I. POT

E-ESTIMATED. F-FORMER INSTALLATIONS, TOTAL HORSEPOWER. A-ADDITION ① HOUSE LOAD INCLUDES ALL POWER USED TO OPERATE AUXILIARIES ② PLANT LOAD FACTOR EQUALS RATIO OF AVERAGE LOAD TO PEAK LOAD OF POWER PLANT
③ MACHINE LOAD FACTOR EQUALS RATIO OF AVERAGE LOAD TO THE RATED CAPACITY OF THE SPECIFIC ENGINE DURING A PERIOD OF ONE YEAR. ④ TEMP AT RATED LOAD. ⑤ FIGURES GIVEN ARE FOR THE TWO MONTHS OF OPERATION SINCE STARTING
⑥ WATER FOR COOLING TAKEN FROM CITY MAIN ⑦ AIR INTAKE DOUBLE CONCRETE CHAMBER MUFFLERS ⑧ ELEVATION 2150 FT.

dium, is frequently substituted for water in piston cooling systems. Where oil is used, it is necessary to provide water cooling for the oil. Advantage of the use of air filters, especially in dusty locations, has been demonstrated by decreased wear. Use of refining agencies reduces the amount of attendance required by permitting longer runs between inspections and fewer repairs and replacements.

Speeds and Weights

Review of speeds and weights in present practice by the N.E.L.A. shows rotative speeds in central station

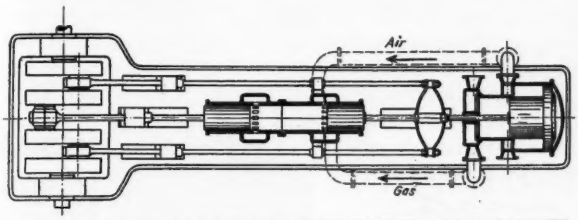


FIG. 1. DOUBLE-OPPOSED PISTON CONSTRUCTION SHOWING DIAGRAMMATICALLY HOW AIR AND GAS ARE ADMITTED AT ONE END OF CYLINDER AND SPENT PRODUCTS DISCHARGED AT THE OTHER END IN THE OECHELHAUSER SYSTEM

practice to vary from 94 to 300 r.p.m., a recent installation operating at 600 r.p.m. Weights vary from 90 to 375 lb. per hp. A weight of 350 lb. was normal formerly. In marine service, rotative speeds are somewhat higher and weights vary from 15 to 150 lb. per hp. Diesel engines for the German battle cruiser Ersatz Preussen weighed 20 lb. per hp. and those for some new German cruisers will weigh 5 lb. per hp. The engine used by the Packard Motor Car Company for its airplane weighed only 2.9 lb. per hp. Diesel locomotives operate at from 250 to 800 r.p.m. with weights ranging from 20 to 70 lb. per hp. While, a few years ago, a piston speed of 800 f.p.m. was considered normal, reference to Table II will show that piston speeds up to 1500 ft. have been reported.

No increase in unit capacity over the 15,000-hp. Diesel engine in Hamburg, Germany, has been effected in stationary practice. A 17,150-hp. M.A.N. engine was built for a German warship. The Ersatz Preussen will have 16 3120-hp. engines, each having 10 cylinders of 2-cycle, double-acting type. Reference to Table II indicates that American builders are prepared to offer engines in sizes up to 15,000 hp. Capacities of 10,000 hp. are frequently reported in Germany.

An explanation for the apparent reluctance on the part of American power producers to install Diesel units of very large size may lie in the fact that the fuel economy of Diesel engines increases only slightly with increase in size, therefore the growth of the plant may more nearly follow the demand and the installation of a number of smaller units permits of better loading of all operating units and of easy inspection and adjustment before serious trouble arises.

Diversity of opinion regarding the relative merits of 2-stroke and 4-stroke cycle is due to insufficient scavenging under present conditions in the former system as is indicated later in our remarks on scavenging. Many builders who employ both systems use the 4-stroke cycle for smaller units and the 2-stroke for large units or the latter for installations at which supervision is less expert or less thorough. Marine practice appears also to favor single-acting construction. Of 181 motor vessels of 1000 gross t. completed in 12 countries during the past year, 115 were four-cycle and 66, two-cycle engines. The types of cycle adopted in 18 vessels of 10,000 hp. were evenly divided. Although Germany standardized on two-cycle engines for submarines before the war, the four-cycle system has been adopted since. On the other hand, both 15,000 and 17,150-hp. German engines previously mentioned were of the two-cycle type. Foreign practice favors the four-cycle system for sizes of 100 to 1800 hp. and 2-cycle for sizes of 3000 to 15,000 and over.

Unlike steam-motive-power machinery, whose impelling medium steam is homogeneous, the motive process in internal-combustion engines involves chemical reaction which takes place within the cylinder hence increase in unit cylinder sizes is controlled by factors much more complicated than mere structural considerations. Flame propagation, turbulence of charge, methods of fuel and air admission and scavenging of burnt products are vital factors. Notwithstanding these limiting agencies, we find the cylinder output of the 17,150-hp. M.A.N., two-cycle engine to be 2860 hp. American builders have produced cylinder outputs of 450 hp. in four-cycle, single-acting engines and 625 to 750 hp. in double-acting, two-cycle and four-cycle types. One American builder is prepared to produce engines with cylinder capacities up to 1500 hp.

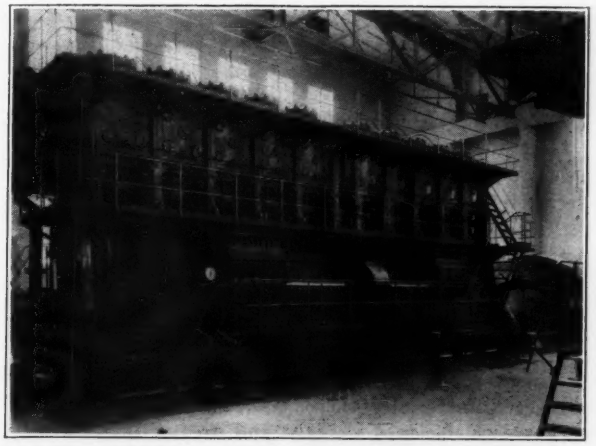


FIG. 2. LARGEST STATIONARY DIESEL ENGINE INSTALLED DURING THE YEAR. ONE OF TWO 11,700-HP. UNITS OF THE HENNINGSDORF, GERMANY, PEAK LOAD STATION

Turbulence Aids Combustion Process

Turbulence of charge has been demonstrated to be an active agency in increasing the rate of heat transfer between the air and the oil spray and in increasing the time of ignition of the combustible mixture. Establishment of turbulence of the charge and rapid distribution of the fuel by adequate spray methods is of particular importance in solid injection engines because of the greater difficulty of distributing the oil charge finely and uniformly. This is the principal reason for giving preference to air injection of fuel, notwithstanding the greater complication introduced through the requirement of an air compressor. Air injection also permits greater latitude in the use of fuels. But diligent investigations that have been in process for the past few

years by Dr. P. H. Schweitzer at the Pennsylvania State College and W. F. Joachim, at N.A.C.A. Research Laboratory, Langley Field, Va., give much promise of providing data with which spray injections may be controlled properly.

Supercharging gives promise of much wider application particularly with two-cycle engines. Motor-driven blowers and exhaust-gas turbines now are being employed for raising the pressure of inlet air. This subject will be discussed more at length in a subsequent issue of this magazine.

Unlike trends in steam power, operating temperatures and pressures within Diesel engine cylinders are much the same as those employed by Dr. Diesel. Injection pressures have reached a high limit of 6000 lb., see Table II, with a view to promoting better mixture of charge but the usual 500-lb. compression pressure is rarely exceeded. The thermal efficiency of the Diesel engine, which is inherently high even for small sizes, has power more cheaply than can be done in Diesel plants. Since there are no standby losses under the Diesel system, this type of motive power is adapted especially well for standby or peak load duty in central station or other power service.

Purchasers of power, however, are not interested in relative costs of producing power. They are vitally interested in what power costs them either through purchase or through a self-owned plant of a size possible in their case. Therefore, the Diesel engine finds a place in many municipal and industrial plants where power may thus be produced at much below its purchase price. The economic limit in capacity of Diesel plants for any kind of power depends upon the purchase price and cost to produce power under the particular conditions in the location of the prospective purchaser or producer. Reliability of Diesel power is such, at the present time, that some industrial plants install such power in preference to purchasing power.

TABLE II. DIESEL ENGINE DATA

Mfr.	Cylinder Range Dia. & Stroke	Crosshead or Trunk Piston	Piston Cooling Water or Oil	HP range	Hp. per Cylinder Range	Cycle 2 or 4	Action single or double	Type Fuel Injection Solid or Air	Cylinder air Compression	Compression pressure lb./ sq.in.	Fuel Injection pressure lb./sq.in.	Normal B.M.E.P. lb./sq.in.	R.P.M. range	Piston Speed ft. per min.	Wt. per hp.	Floor space sq.ft. per hp.
1	9½ x 11 23 x 28	both	on 23 & 28 only	100-2000	33-1/3- 200	4	S	Solid-small Air -large		475	4200 & 1930	70 & 94	750-200	1150-831	50-200	
2	4 x 6 6 x 8	trunk	none	92-130	23 - 30	4	S	Solid	Piston	380	5000 to 2000	75	1000-200	1450	90	0.6
3	17 x 23 29 x 44	crosshead	both	860-4000	220 - 670	2	S	Air	Piston	470	7.0 to 1150	65 to 72.5	257-128	900-985	155-228	2.75 - 2.3
4	8 x 12 22 x 30	7 to 24 in.cyl C above 24 in.	Air on small trunk type, Oil on large type, water on crosshead type	80-9000	25 - 900	4	S except in very lge	both	Supercharger	500	1000 Air 2000 Solid	75	100-800	900-1500	75-370	0.16
5	6 x 8 13½ x 17	trunk	none	40-300	15 - 65	4	S	Solid	Piston	400-425	1000-6000	75	275-750		50-150	
6	20½ x 27½ 27½ x 47½	crosshead	both	2000-15000	300 - 1000	2	D	both	Piston	500	Up to 4000	65	100-225	800-1000	75-175	0.33
7	13 x 18	both	none	90-400	50 - 125	2 semi 4 Diesel	S	both	Piston	350-425	3000-4000			900		
8	6½ x 9½ 14½ x 19	trunk	air	90-500	15 - 80	4	S	Solid	Piston	35-400	3500-4500	50 - 95	275-750	650-825	54	
9	9 x 12 22 x 30	trunk	none	80-190		4	S	Solid	Piston	550	1300-1500	65	300-750	900	50-220	
10	4½ x 6 14 x 18	trunk	none	25-800	17½ - 100	4	S	Solid	Piston	500	4000-5000	94	500-700	788-1800	60-175	0.15 - 1.75
11	9½ x 10 14½ x 15½	trunk	none	80-300	30 - 75	2	S	Solid	Crankcase	175	1000	30	277-525	800	130-300	0.85 - 1.0
12	10½ x 15 20-7/8 x 22	trunk	Oil in large type	110-2000	55 - 300	4	S	Solid	Piston	500	3000-4000	75 - 100	200-350			
13	6 x 6½ 16 x 20	trunk	Oil in large type	25-1400	12½ - 175	2	S	Solid	Crankcase				300-257			
14	Up to 30 x 52	both	both	100-15000	Up to 1500	both	both	Solid	Pump or Blower	500			90-400			
15	9½ x 10½ 18 x 22	trunk	none	90-1800	25 - 185	4	S	Solid		370	5000	85	333-700	800-1200	50-125	
16	17 x 23 - 18 x 25 8 x 10½-12½ x 20 10½ 10½-12½ x 15 28 x 40	trunk trunk crosshead crosshead		880-1000 50-400 75-540 3000-8000	180 - 135 25 - 100 37½ - 90 700 - 1200	4 4 2 2	S S S D	Air Solid Solid Air	Piston Piston Piston Supercharger				225 277-514 277-527 100-138	693-940 900-925 370-740 650-855		

not been materially increased. A small increase in mechanical efficiency is noted and greater increase may be expected through the introduction of the refinements which have been discussed.

Heat Recovery

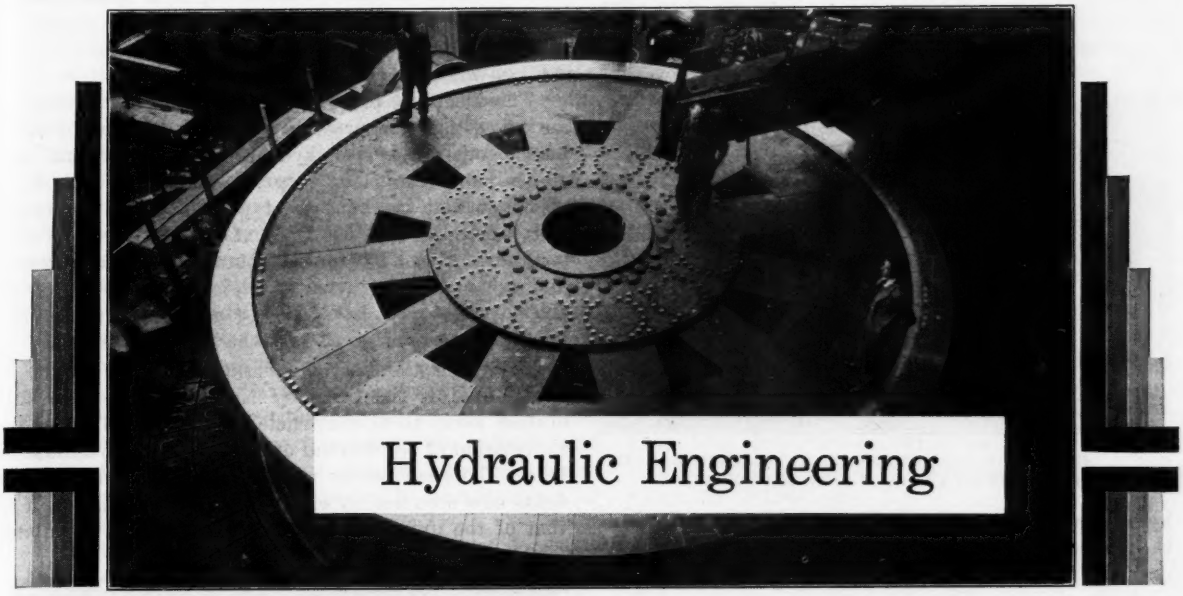
Use of heat exchangers in Diesel plants is becoming common. Practice favors heat recovery from exhaust gases rather than from jacket water because approximately one-third of the total heat in the fuel supplied to the engine may be thus reclaimed. Waste heat boilers are being installed increasingly not only to provide heat for the power station itself but for warming other buildings and for the operation of small auxiliaries.

Although a number of utility companies have installed Diesel engines for permanent use due to special fuel and water conditions, Diesel engines are not generally used for this purpose except in new territory in which case they are transferred to another new territory as soon as the station can be economically connected with a high-power line. Since a Diesel plant may be quickly installed and quickly and easily moved, this type of motive power has a real place in this service. It is conceded that a modern, well equipped and well managed steam turbine plant of large size can produce

Application of Diesel power continues to spread. It is increasing its lead over all other types of power for marine purposes. The gross tonnage of motor ships reported under construction during the year 1929 was 1,395,868 t. while that of steam was 1,211,533 t. One German manufacturer reports that designs have been submitted for Diesel equipment amounting to from 120,000 to 180,000 hp. for four ships. Principally because of the relative fuel conditions, America lags behind most foreign countries in Diesel application.

Speed-torque characteristics of Diesel engines, together with their standby advantage, place this type of power in preferential position for locomotive switching service especially in metropolitan centers where there are smoke abatement restrictions. Where main lines are electrified, the Diesel locomotive has its place in the railroad yards where cost of electrification is excessive.

That Diesel power has earned a sure place in the power field may be appreciated when it is realized that the engine illustrated in the headpiece of this article ran one year and 20 days without stopping and without requiring adjustment or replacement. Shut down at the end of this run was not forced. Previous non-stop runs of this 8-yr. old engine were for 90, 142, 211 and 272 days.



Hydraulic Engineering

Recent Progress in Hydraulic Engineering

DEVELOPMENT OF FREQUENCY AND LOAD CONTROLS, LARGER UNITS, MODEL TESTS, RESEARCH ON DAMS, SHOW PROGRESS STEADY EVEN IF NOT SPECTACULAR. BY BYRON E. WHITE

IN HYDRAULIC ENGINEERING, as in many other fields of human endeavor, it is a fact that marked progress and striking or important new inventions or developments are often separated by periods of time beyond the span of a twelve-month. It so happens that in preparing a review on this subject for the past year, there is little of absolute novelty or of the very spectacular to record. There has, nevertheless, been distinct progress in the field of hydraulic engineering during this period but this progress was essentially along lines previously mapped out and has been due to the extension of methods, principles, and equipment described in previous years.

Out of the problems and conditions arising from great interconnected systems has come the necessity for extremely close frequency control, in order that each plant and group of plants may carry its allotted share of the load and perform without undue disturbance to its immediate system and the major system with which it is connected. The tolerance within which frequency must necessarily be maintained in order to accomplish this purpose is but a fraction of the minimum variation capable of being indicated by standard frequency meters. For this reason, as well as the relative inaccuracy and slowness of hand operation, it has become necessary to devise other means for maintaining constant frequency within extremely close limits, with a refinement impossible by manual means. This necessity has resulted in the development of the various automatic devices for maintaining frequency, which are now on the market.

As a corollary, the researches in this direction, as well as the necessities of the case, pointed to the possibility of also automatically controlling load distribution between units or plants, which is now successfully done, resulting in average operating efficiencies very much higher than is obtainable with the best hand operating methods.

Such devices, which are superimposed on steam and

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After vacation time employment on a State land and topographic survey in 1895, followed by part time work in several succeeding years in the New York State Engineer's Department, and the U. S. Geological Survey, he was assistant city engineer of Rome, N. Y., in 1901, mechanical draftsman 1902-3, and since 1903 has been identified principally with water power and public utility work.

With the exception of a few months in 1909-10, he has been civil engineer, engineer and general engineer of Utica Gas & Electric Co. since September, 1905, dealing principally with matters directly or indirectly connected with water power and storage.

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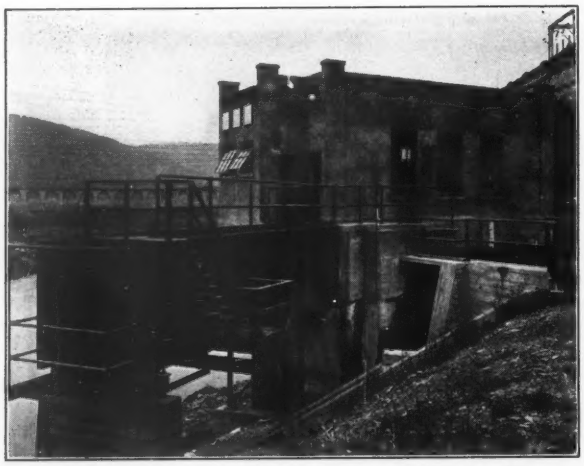


FIG. 1. EXTERIOR OF HOLTWOOD HYDRAULIC LABORATORY, PENNSYLVANIA WATER & POWER CO.

hydraulic turbine governors, supervising and controlling their action, maintain frequency within limits that were previously undreamed of or were considered highly improbable or impossible.

Size of Units Increases

Larger and larger generating units are being planned and constructed from time to time. This tendency has grown out of the immense aggregations of power interconnected into single systems and the dissipation of the necessity for maintaining a considerable number of small or medium size units in order to have proper reserve capacity. In water power installations, the maximum size of unit is dictated often by the minimum water supply or the minimum load which the station may conceivably be called upon to carry in such a system, which latter manifestly may be much larger than with small, independent systems.

For low head installations, the adjustable blade propeller type turbine, with its flat efficiency curve, makes it possible to operate efficiently at relatively small gate openings, thus permitting the installation of much larger units for a given efficiency at minimum load than would be possible with reaction or fixed blade propeller type machines.

A further limit, which is elastic, is that of the ability to ship and handle the largest piece of a unit, which is easily overcome by subdividing the runner, casing, generator and so on, into a number of smaller parts and assembling and doing the final work upon them at the site.

Installation of generating units, transformers, and transmission circuits as single units has been aided by the same circumstances, and is now much more universal than in the not distant past. Simplification, through elimination of auxiliary buses, low tension generator oil switches, and other equipment, has often been carried to extremes unthought of only a brief time ago, which results in the utmost of simplification, economy in cost, and ease of operation, not to mention the reliability of the combined unit.

Vulnerable points in hydroelectric installations, such as conduits, are being more and more supplied with automatic shutoff valves, automatic weirs and other protective equipment intended automatically to shut off the flow of water in case of accident, to a much greater extent than heretofore.

Value of Model Tests

The technical press of the last year has chronicled an increasing number of instances where tests of small homologous models of hydraulic structures and machines have been made to great advantage, both as to efficiency and in the cost of the completed structure. Not only have the facilities of many university and technical college hydraulic laboratories been increased and new ones constructed or projected, but some of the power companies have also constructed laboratories wherein results of great value have been obtained.

Crowning the list of laboratories which might be enumerated is the proposed National Hydraulic Laboratory about to be constructed and operated under the supervision of the Bureau of Standards, at Washington, D. C. This laboratory will scarcely invade any of the fields now occupied by existing laboratories, unless it be that of the university laboratory, since it is prohibited

FIG. 2. INTERIOR OF HOLTWOOD HYDRAULIC LABORATORY, PENNSYLVANIA WATER & POWER CO.

by law from entering private commercial work. It is, however, charged with the duty of performing experiments, both theoretical and on a practical basis for the various government departments, in the course of which much valuable data of interest and value to the hydraulic engineering profession is bound to be made available. In addition to this, the laboratory will undoubtedly follow the lead of the Bureau of Standards by delving into hydraulic phenomena concerning which little is now known, the results of which will undoubtedly be made available to the profession as a whole and thus increase the sum total of knowledge of hydraulics to a marked degree.

It is devoutly to be hoped that the National Hydraulic Laboratory will work on a truly friendly and cooperative basis with the engineering profession in general and with other hydraulic laboratories in particular, in order that there may be no unnecessary duplication of work and that, on the other hand, the knowledge of hydraulics may be most rapidly and economically increased.

Among the laboratories in the United States and Canada are two private power company laboratories at which particular attention has been given to the subject of cavitation of hydraulic turbine runners and parts, with gratifying and encouraging results. These are the laboratories at Holtwood, Pa., of the Pennsylvania Water & Power Co., and of the Shawinigan Water & Power Co. at Shawinigan Falls, Quebec.

It is reported that at the Karlsruhe, Germany, laboratory, it has been found possible to make reliable accelerated cavitation tests by the use of light metals and fractional heads, correctly duplicating results found with full heads and full-size homologous machines.

In addition to the many model experiments relating to water power, there are also experiments in progress at the University of California for studying the action of waves on sea beaches and the effectiveness of various types of shore protective structures; the velocity and mode of travel of sea water released into fresh water pools from locks; and the operating characteristics of jet pumps and of disk friction pumps.

Experiments with the small scale model of the Spier Falls forebay and conduits resulted in the saving of a large amount of money in construction and in the "down time" of the old plant during its enlargement, as well as a better design from the standpoint of hydraulic efficiency. This is but one of many similar examples which might be quoted.

Research

Research along economic lines has also been extended in the past year. Much work has been done along the lines of design to reduce hydraulic and machine frictional losses and to increase the life of important structures and machines. This research has been carried on by not only manufacturers of hydraulic power equipment, but also by various private engineers and power companies. Certain of the power companies have found it to their advantage to foster such studies by offering bonuses for improved performance and reliability, which have enabled manufacturers to indulge in the necessary studies and experimentation which are so necessary to the bringing about of such results.

The Kaplan turbine with governor adjustable blades has been a favorite abroad, where applicable, for a considerable number of years. Its first use in the United States is a matter of recent history, as compared with the use of the fixed blade and the more recent hand-adjustable-blade type of propeller turbine. The successful application of this type of turbine in Texas has been followed by a number of installations and projected installations of this type of machine, while the use of the hand-adjustable blade machines has become rather commonplace. Their economic advantages, as well as their advantages from the standpoint of flexibility of operation are great and are coming to be more generally realized.

FIG. 3. SETUP OF MODEL OF SPIERS FALLS HEADRACE AND PENSTOCKS, 1/50 SCALE, AT ALDEN HYDRAULIC LABORATORY, WORCESTER, MASS.

The Spiers Falls, N. Y., turbine of 57,000-hp. capacity under 81 ft. head, of the New York Power & Light Corp., is of the largest physical dimensions constructed to date. Other units of practically equal size have been constructed during the past year for the Russian Dnieprostroy development and for certain Canadian installations.

Trends in Details of Design

Runners made up of pressed steel blades cast into cast steel or cast iron hubs and runner bands have also found increased favor during the past year. In regard to bearings, the oil-lubricated babbited type and the rubber type appear to be gaining in popularity, the latter being of particular value in connection with propeller type turbines where the bearing itself is relatively inaccessible.

There is an increasing tendency to the use of butterfly valves, brought about by improvements in the design of the valve and the operating mechanism, particularly by the development of means for keeping them reasonably tight when closed, and of reliable automatic operating devices. It has been found possible by experiments in California to utilize this type of valve as a free discharge valve, although it is not recommended for use for extended periods in this application. Valves of larger diameter and for higher heads than heretofore, have been manufactured and installed during the past year, notably the automatically-operated cast steel valves operating under 836-ft. head at the Waterville, N. C. Plant, on the Pigeon River.

The higher speeds possible with the propeller or axial type turbine have greatly increased its field of usefulness, partly because of the decreased size and cost of the necessary generators. The utilization of rolled steel and electric arc welding in the construction of generators has also had an influence in the direction of decreased cost, the lessening of weight and consequent ease of transportation, as well as the ability promptly to construct machines of any desired dimensions, which is, of course, much more difficult and costly with cast frames and other generator parts.

The recently-developed umbrella type of generator, having a single combined thrust and roller bearing, has been further improved by lowering the position of this bearing into the bracket beneath the generator, thus decreasing the head room somewhat, which is an advantage in many locations.

Design of the true outdoor type of generator protected only by a metal covering has been greatly improved during the past twelve months. Such machines are particularly adapted to remote locations where trans-

portation is difficult and costly, as well as to the smaller installations where the cost of the customary power house might be prohibitive.

Use of other fluids than oil for hydraulic turbine governors is rapidly decreasing. In many cases, governors are now being installed in pairs, with pumps and tanks of such size and capacity that either may operate both governors, thus leaving one of each pair as a spare, eliminating the necessity for additional spare capacity and economizing in power house space. Motor driven governor flyballs are becoming more and more standard as time goes by. Their past uncertainty in operation has been largely removed by various improvements and changes in the source of energy, the electrical connections and the protective devices. Automatic synchronizing, or speed matching, which was introduced in the recent past, has been found so satisfactory that many installations are now being made, particularly in automatic and partial automatic plants.

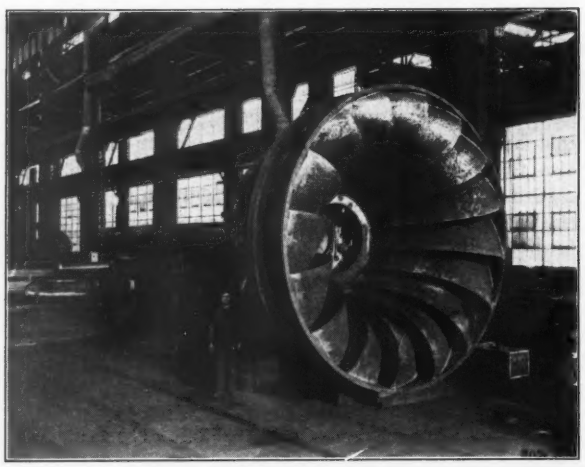


FIG. 4. 39,500-HP. RUNNER, FOR CARPENTER DEVELOPMENT, ARKANSAS POWER & LIGHT CO., MADE BY I. P. MORRIS & DE LA VERGNE, INC. WEIGHT OF RUNNER, 96,000 LB., OF SHAFT, 104,000 LB.

Design of Dams

Devices for dissipating the energy contained in rapidly flowing or falling water are still receiving considerable study. At the Arapuni, New Zealand, plant, diffusers have been installed at the ends of some high head penstocks for diffusing as much as 3000 c.f.s., which falls in a harmless spray on the surface of a pool, thus obviating the construction of expensive works for otherwise accomplishing approximately the same object.

Hydraulic laboratory model experiments on the proposed section of the dam for the Safe Harbor, Pa., development, on the Susquehanna River, have resulted in the selection of a concrete apron at the foot of the spillway inclined 26 deg. above the horizontal, in which the sheet of water from each spillway gate is confined between dividing walls which are carried clear out to the toe of the apron. Experiment indicates that the sheet of water will be discharged a sufficient distance downstream to avoid any danger to the dam from erosion.

It is claimed that the problem of economically producing power from the tides has been solved in Europe. In a recent American engineering periodical appears a description of the experimental plant. Sea water at high tide is admitted through gates or sluices in an embankment or dam into a storage basin, generating power when the head or difference of water level is sufficient. Part of the power is transformed into electrical energy by means of a generator, the balance being absorbed by a frictional brake device mounted on the shaft between the turbine and electric generator. Water is passed through this device, where it is heated to about 390 deg. F., corresponding to 200 lb. pressure and is then stored in an insulated steam accumulator.

When more energy is demanded than the water turbine can deliver, steam from the accumulator is passed through a steam turbine, driving its connected electric generator, which operates in parallel with the water wheel driven generator, or independently.

When the difference of level between the water in the basin and in the sea becomes, at low tide, great enough to generate power from water flowing back again to the sea, the water wheel again generates power until the head is again reduced. The governor acts on the water supply to the brake, rather than on the hydraulic turbine gates, as is customary. It is claimed that by this intermittent operation of hydraulic and steam turbine driven generators, a fairly constant electrical energy supply may be maintained.

Other Forms of Power in Conjunction with Water Power

Oil engine power in the form of Diesel or modified Diesel engines is coming more and more into competition with hydroelectric power. Likewise, the vast quantities of natural gas, which have hitherto been allowed to escape into the atmosphere in the oil fields of California, whose conservation has now been required by law, have made gas-fired steam power plants more economical than hydroelectric plants in that State. Recent news dispatches indicate that a vast transmission and distributing gas main system has been laid and that the further development of water power in California has been largely halted or delayed by this development. Ever recurring droughts in California during the last few years have convinced those responsible for the maintenance of power supply that they must place a much greater reliance upon fuel-generated energy than in the past, in order that reliability and continuity of service may be fully maintained at an economic cost.

Working hand in hand with these conditions is the continued improvement in efficiency and consequent reduction in the cost of energy produced by fuel power plants, which have had precisely the same effect throughout most of the United States. Consequently, the range of choice of favorable hydroelectric sites yet undeveloped has been still further narrowed by the economic situation, as well as by the previous development of those which were most favorable.

In many sections the choice between steam power and water power is most debatable. Curiously, however, in the Pennsylvania coal fields, where coal is most abundant and cheap, hydroelectric development on a large scale has been going on at a rapid pace during the last several years. This has been brought about largely because of a recognition of the enormous advantages of so-called overdeveloped hydro for peak load

operation, and the possibility of quickly getting reserve hydro capacity on the line in an emergency. A more general appreciation of these possibilities and their value would undoubtedly result in the building of many hydro projects now considered uneconomical when designed for operation at medium and high load factors.

As is the case in every other field of engineering activity, research along various promising lines is continuing apace. The causes of the pitting of water wheel runners, draft tubes and other parts, are still being assiduously sought, but as yet there is no harmony in the tentative conclusions reached by the various investigators. There is still the same uncertainty as to whether or not pitting is the direct result of chemical or mechanical action or erosion, or a combination of the two. A number of independent researchers are continuing the study of this subject.

Meanwhile, the experience of a large number of companies with regard to the repair of pitted areas by means of welding, as well as the use of welding for other purposes, has been gathered by the Hydraulic Power Committee of the National Electric Light Association and is about to be published.

It is encouraging to the purchasers and users of hydraulic equipment to note that there has begun a tendency for competing manufacturers to pool their patents and hitherto private secrets for the purpose of harmoniously working together in the production of power equipment, as is illustrated in the case of the production of the turbines for the Safe Harbor, Pa. development of the Pennsylvania Water & Power Co., by two different manufacturers from substantially identical designs.

Forecasting of water supply, a matter of such live interest to the operating officials of hydro power companies, promises to become a much more reliable art, at least comparable with our daily weather forecasts in accuracy, in the not distant future. The prevailing drought of the past summer was correctly forecast by Streiff at least two years in advance. In many areas, nearly as severe conditions are forecast for 1931, with much better water years to follow. His work, supplemented by that of other associated or independent observers and investigators, promises to gain in the certainty and general acceptance of its results.

Improvement in Entire Field Is Steady, Though Not Spectacular

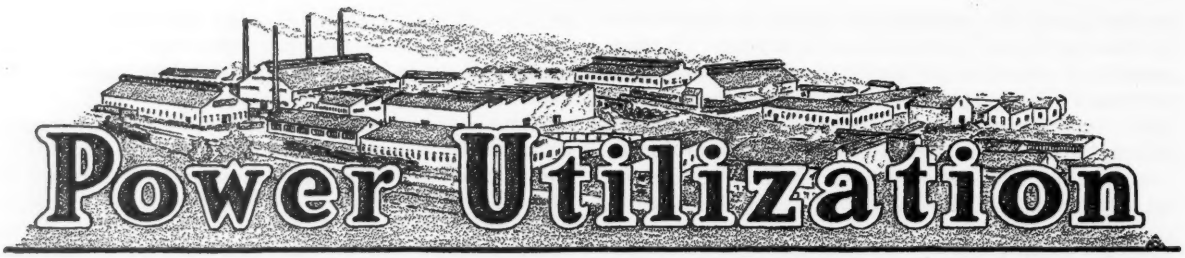
While there is a feeling on the part of some that hydraulic engineering has become static, with little in the way of improvement to be discovered, various experimenters, particularly those engaged in the conduct of hydraulic laboratories, and engineers engaged in designing large or novel structures, machines or projects, are constantly bringing forth innovations or improvements upon old designs and methods of a worthwhile economic character. It is safe to say that so long as the hydraulic engineer preserves his independence of thought and action, his initiative, his inquisitiveness, and his imagination, there will continue to be valuable improvements in this field, although we may not expect to see the spectacularly striking ones chronicled annually.

The objects of research in this, as in many other fields, are at the present time predominately economic in their objective and while the apparent room for improvement may seem small, researchers may still confidently expect to be rewarded by results of considerable value.

As an example of a subject on which opinion is diametrically diverse, may be mentioned the design and construction of dams. In a recent questionnaire, which was quite fully answered by a large number of representative and competent engineers, it was clearly indicated that there is still a tremendous diversity of opinion as to many of the important questions involved in the selection of a type of dam to suit given conditions, and the details of its design and construction. A competent committee now has this matter in hand, and it appears highly probable that much may be done in the next few months to clarify this exceedingly complex and difficult subject. Several other national and international committees are working along much the same lines and a coöperative working basis is being sought.

FIG. 5. NEW WATER WHEEL TESTING FLUME, ALDEN HYDRAULIC LABORATORY, WORCESTER, MASS.

In closing, the writer hopes it is not amiss to impress upon his readers the coöperative character of engineering research and the value which is bound to accrue to the individual engineer from cheerfully and promptly doing his part whenever called upon for information or suggestions within the limit of his knowledge and experience. The accumulated mass of knowledge which is available to every engineer has been slowly built up by the accretion of bits of knowledge and experience acquired and contributed by innumerable of our predecessors. By drawing upon it ourselves, we individually assume a moral obligation to put back into this reservoir of information such bits as we may from time to time become possessed of, in order that the pool may be replenished and enlarged, and we be not debtors to those more unselfish than ourselves. This we can do by freely making available to others through private conversation, articles written and published in the technical press, or papers or discussions contributed to technical societies, the theory or details of matters of general interest, of which we become aware in the course of our daily work. By so doing, we shall have the happy consciousness of him who realizes that it is even better to give than to receive.



Ventilation Systems for Industrial Plants

AIR NEEDED, TYPES OF FANS, CENTRALIZED AND UNIT SYSTEMS, UPKEEP OF PLANT. BY T. H. BOOTH*

IN YEARS GONE BY, the industrial plant was a centralized location for certain operations of manufacturing. An aspiring manufacturer built a building according to his ideas to provide about the amount of space he could use. There was little regard for the convenience of handling materials into, between operations, and out of the plant. We now see the greatest care taken in the design of industrial buildings to facilitate and reduce handling. The ingenious and complicated conveyor systems are prime examples. The open one-story building naturally lends itself to the use of conveyors and electric trucks and this has helped the lighting situation greatly. Formerly, if the workman needed more light, he was usually provided with a small light to give local illumination at the working point. Industrial and lighting engineers have proved conclusively the gains in production and in employe health and morale to be realized by provision of adequate lighting by glass and electricity.

Another feature in the march to higher efficiency and employe welfare is the use of air in the proper condition and quantities in the truly modern plant. Fans were probably first used in this way to exhaust foul air and vapors from particularly bad rooms and to supply heated air to large spaces. From that beginning some 40 yr. ago, ventilation has progressed into an art with considerable background and broad applications. Proper ventilation enables one to do more with less effort and feel better at the end of the day's work, Fig. 1. We have to depend on fans to do this just as we depend on electricity to give uniform lighting throughout the day. The open window cannot give the desired results on any size scale. Also, many states have labor laws requiring exhausters on special applications such as grinding and buffing wheels, pickling and plating tanks and spray paint booths.

*Buffalo Forge Co.

FIG. 1. DISC FANS MAKE VENTILATION SIMPLE

How Much Air?

Selection of apparatus is usually an engineering problem the first consideration of which is the object to be accomplished. This may be anything from helping conditions in a particularly hot or unhealthy corner, providing fresh air or combined heating and ventilating of very large spaces, to obtaining exactly the correct air conditions for the manufacture of tobacco or textile products. In the first place, it is easy to determine the space to be served. Next, there are certain well defined standards of ventilation, expressed in the frequency of air change, that is the number of minutes taken to deliver to or exhaust a volume of air equal of that of the room. For instance, 10 to 12 min. is good for an office while, for a laundry, 5 min. would be none too generous and, for other types of work, values to suit the workers' needs and the process.

Use of Disk and Propeller Fans

Having determined the amount of ventilation necessary, next comes the means to secure this. Taking first the simple problem of localized ventilation, we find the disk or propeller fan most commonly used. A hot or smoky room, such as a blacksmith shop or heat-treating room, can be made much more comfortable and cleaner by installing disk fans of proper capacity in the windows or walls away from the direction from which the wind usually blows. These fans will move a large amount of air per horsepower of motor installed but the precaution must be taken to put them in such position that the prevailing draft from the wind aids rather than counteracts the work of the fan, as this type does not develop much pressure. Disk fans may be used to exhaust from working points, Fig. 2, such as paint spraying positions and may be used with piping, if the airflow resistance of the piping is low. The result is low first cost, low operating cost and satisfaction under correct conditions.

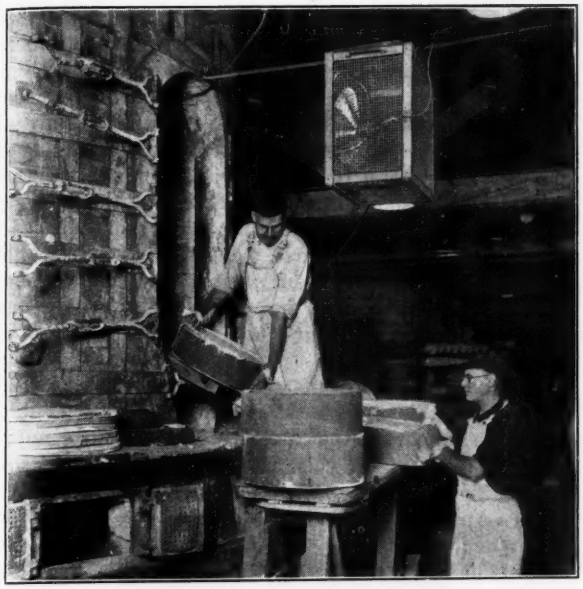


FIG. 2. LOCAL COOLING MAKES FOR COMFORT AND BETTER WORK

For any disk fan the characteristic, is, however, a sharp variation in capacity with change of back pressure upon it. The noise of a large number of units and the wall space taken up make this type of fan undesirable for any general ventilation proposition. In any general scheme, heating will be considered at the same time, in most localities in this country, because of the marked advantages of indirect radiation. We will consider the use of unit heaters later. For general ventilating and air conditioning jobs, the centralized or the unit system is used or a combination of these.

Centralized Systems

In the centralized system centrifugal fans, Fig. 3, supply fresh air and exhaust fans, if necessary, remove the stale air, with piping and suitable outlets to distribute the air evenly and without annoying drafts.

Ordinary practice is to supply air near or directed toward the floor from outlets evenly spaced over the area, Fig. 4. Naturally, the higher the velocity at which the air can be moved the smaller the duct for a given amount of air. The limiting feature is the noise and the horsepower required to reach high velocity. High velocities would be allowable in a machine shop whereas for a small parts assembly room about 600 to 800 ft. per min. would be more suitable. The noise limit for the fan is the velocity through the parts of the fan, of which the velocity at the outlet is used as an index.

Well-tried performance data enable the engineer to pick the size fan of any type to secure the capacity at an estimated pressure using a certain horsepower. The most common errors in selecting fans are in estimating the resistance of the duct work bends and elbows.

For the central system, a single operating unit offers the advantages of higher efficiency than a number of small units. It can often be installed in otherwise waste space without cutting into useful floor or headroom. One unit requires about the same amount of attention regardless of size. Then, too, automatic controls can be economically installed on the central unit, such controls being particularly needed when heating or cooling, air-washing and conditioning apparatus are added.

For the ordinary shop, nothing more than heating will be considered, though the thought has often been expressed that it would be worth a lot to have washed and cooled air during the summer months. During the last 5 yr., conditioned air has come to be a requisite in the larger movie theaters and is indeed one of the drawing cards in the summer months. Banks, offices and stores are regularly installing complete air conditioning equipment. With the progress of dust elimination, general ventilation and other steps for reducing fatigue, it seems only a matter of time before we shall have washed air of controlled humidity and temperature throughout the year. Apparatus is now installed for numerous special applications such as textile mills where air of proper humidity helps to make a better quality product by decreasing breakage due to dryness of the fiber, in electric cable plants where the strength of the paper insulation is dependent on the correct amount of moisture; also in cigar manufacturing plants where the leaf must be kept uniformly at the best condition to avoid breakage and scrap and in the assembly rooms for precision apparatus where all dust and lint must be avoided. New uses are constantly being found where controlled air conditions will produce a positive saving.

Unit Heater Systems

Heating of manufacturing space, and I speak of heating first because that has been the primary object of the combined heating and ventilating, has come to mean unit heating elements, in the majority of cases. The unit heater comprises a heating element of the extended surface type with one or more disk or centrifugal fans to drive a large volume of air over the heating coils at a velocity sufficient to reach the floor and give a good distribution of warmed air. The advantages of this method are the elimination of the large ducts necessary with a central system, also compared to the use of direct radiation the first cost is lower. Extensive cast iron and pipe radiators not only take up usable floor space but make localized hot and cold spots and use steam less efficiently, as the heated air flows directly

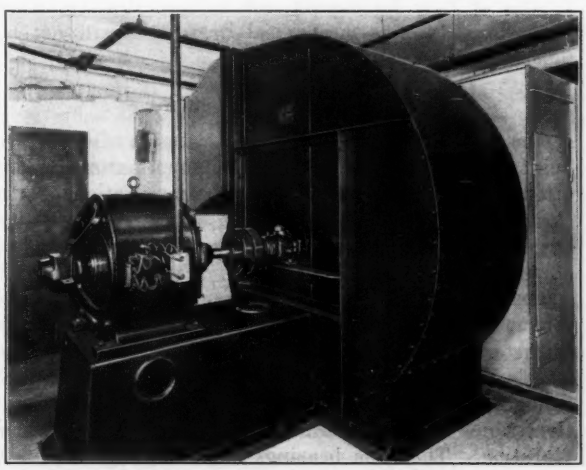


FIG. 3. MOTOR-DRIVEN FAN FOR CENTRAL HEATING SYSTEM

upwards to the ceiling, giving a high temperature where it is useless and larger losses through the roof.

Unit heaters have fractional or low horsepower motors so that the power consumption is small. They recirculate the air keeping the temperature at the floor only a few degrees different from that at the roof. Properly trapped, they return the condensate in an even flow to the boiler. The constant circulation of the air makes for more healthful conditions. Certain makes of unit heaters also incorporate additional built-in sections for washing and humidifying the air, thus making a three-purpose unit.

Generator Cooling

Among the many interesting special applications of ventilation, one is the air cooling of turbo-generators

FIG. 4. WOOD MAIN DUCTS ARE SOMETIMES USED WITH DISCHARGE BRANCHES UNIFORMLY SPACED

and large motors. These units have their individual fans to force clean cool air through the windings and laminations, maintaining the best operating temperature and avoiding the deposit of dirt inside the machine. Air washers clean and cool the air while a fan circulates the air through the machine and back to the washer; all of which must be figured out with due regard of the resistance of the air passages and the heat to be dissipated.

Use of fans for forced and induced draft is more properly classed as mechanical draft and will not be touched in this article.

Noise Can Be Avoided

Installation of ventilating apparatus is often a sore point for the contractor and the manufacturer, more often than not because of lack of appreciation of the care necessary. In the first place, a fan is of necessity large in outside dimensions compared to its weight, horsepower consumed, or rigidity. Yet it must run at comparatively high speed, 1000 to 2000 r.p.m. being common. And the wheel is of comparatively large diameter. Some manufacturers, therefore, give the wheels running or dynamic balance. But that is not enough. The unit must be mounted on a solid foundation, which will absorb rather than multiply any minor vibration. Then the bearings and coupling, if direct motor drive, must be lined up true because, with any unit of the general dimensions of a fan, careless tightening of foundation bolts will pull the shafts considerably out of line. It is much cheaper to give extra care to installation than to try to find the cause of trouble later.

One problem of installation that is a source of trouble on ventilating jobs is noise, especially in offices and quiet workrooms. Noise may be caused by a number of other things than faulty construction of the mechanism. In the first place, the foundation or the securing of the fan to the foundation may allow some play and rattle. This can, of course, be easily fixed. Or the piping may not be tight and securely fastened. Where extreme quiet is desired, noise that is blamed on the bearings or motor is often found to be due to the duct work. In such cases, installing a flexible duct section next to the fan will kill the noise. Canvas makes a good material for this, as it seems to allow enough flexibility to deaden the sounds that are carried on the air column.

Another source of noise is the lack of sufficient end play in the flexible coupling on a direct-connected motor shaft. An induction motor runs at a certain magnetic center and, if set so that it cannot run on center, the rotor will hunt back and forth continually, bumping against the bearings. This makes a rattle that sounds bad but can be easily fixed by moving the motor closer to or farther away from the coupling center.

Frequent Inspection Pays

Now, just a word on operation and maintenance. Lubrication of fan bearings is in no way different from that of other bearings except that excess oil in ring oiling bearings makes an unsightly mess as the strong draft of air entering a fan may carry excess oil into the fan and into the duct work. Ball and roller bearings, now being used to such a large extent, have simplified the lubrication problem, since it is necessary to grease them only at intervals of one to three months even on continuous operation. Antifriction bearings running hot is often a sign of too much or too heavy grease.

Fans working in conjunction with special processes should have much more frequent inspection than ordinary. Acid fumes or abrasive laden air cause more or less rapid erosion or corrosion. Wheels may wear so thin as to cause failure in a short time, if the fumes are stronger than anticipated. Eating away of the metal seldom causes unbalance as the loss of weight is quite uniform but the deposit of paint or other substance on exhaust fans will often build up unevenly. Frequent inspection and cleaning will do much to avoid breakdowns on this service.

Resistance Motor Starter Improves Operation

Last year I was called upon to solve a problem for one of our power customers who is operating a creamery. One of the machines in his plant is a milk separator which must be started gradually. At the time I was called in, this separator was started by gradually moving a belt, by means of a hand wheel from the loose to the driven pulley. As the slippage of the belt on the drive pulley was excessive, frequent belt renewals were necessary.

This method was replaced by gradually starting the motor with the belt on the driven pulley and connected to the load, a semi-automatic resistance starter being

installed to control the starting of the squirrel cage motor.

Although for years I have been using starting compensators for such motors, I have recently found that by the use of a separate resistance control for starting, line disturbance and equipment troubles could be greatly reduced.

Hobart, Ind. HARRY J. ACHEE.

Coil End Wedges Prevent Breakdowns

BY A. C. ROE

ON HIGH-VOLTAGE machines, the ends of the slot portion of the coils extend quite a distance beyond the core, hence unless the coil ends are thoroughly braced, the coil extensions tend to move. Constant move-

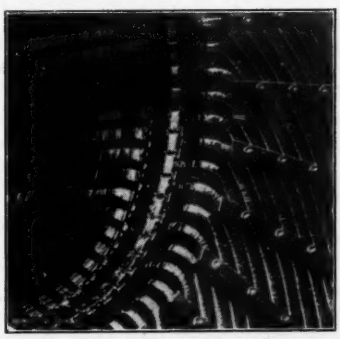


FIG. 1. WEDGES TIED BETWEEN COIL ENDS FORM A SOLID RING

ment, no matter how slight, will crack the slot insulation on the coils at the point where they leave the slot.

To prevent damage from this source, it is possible to install hard wood blocks between coil ends, at both sides of the core, as shown in Fig. 1. The blocks form a solid circle at a point midway between the core and ends of the straight sections of the coils. These blocks extend

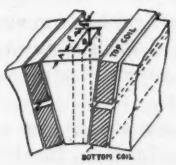


FIG. 2. WEDGE BLOCKS ARE SHAPED TO FIT COIL SPACES AND SLOTTED FOR TYING TO COILS

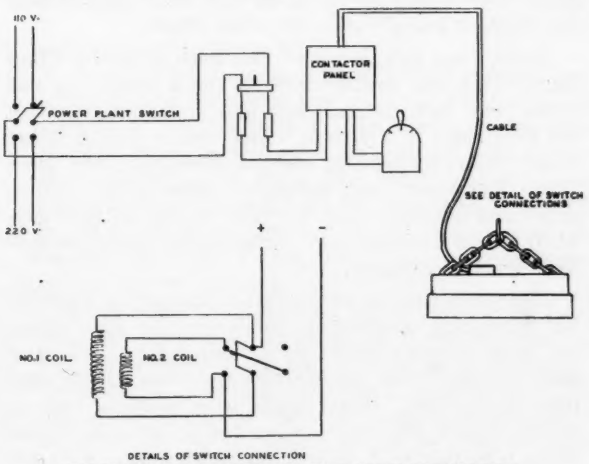
the full depth of the two layers of coil ends and, being a snug fit, tied to each coil, prevent the coil ends from moving.

Blocks are made from maple and, after machining, are treated in hot paraffine. Figure 2 shows the general shape of the blocks, which are cut wedge shaped to fit snugly in the space between coil ends from adjacent slots. Groove B can either be cut through the center of the block, or notched in one side of the block. The advantage of the hole in the center is that the coil is pulled up right from two sides, whereas, with the notch the coil is fastened to one block only; but a snug fit makes the slot block satisfactory and, when rewinding a stator, the notched type of block can be installed with each coil as it is put in.

Torpedo twine ⅛ in. diameter is used to tie the blocks in place, as shown in Fig. 1. These blocks, if properly installed, will reduce breakdowns from grounded coils and, as an insurance against trouble, the cost of installing can be charged to preventive maintenance.

Magnet for 110 or 220 Volts

IN A PLANT where the writer was at one time employed, an electric magnet was used to handle scrap iron. During the day when a large 220-v. generator was being operated, this voltage was used on the magnet



MAGNET CONNECTIONS FOR TWO VOLTAGES

but, at night, only 110-v. power was available. A double-pole, double-throw switch at the power plant was thrown to take the voltage available, while a switch on the magnet placed the two halves of the magnet winding in series for 220-v. operation and in parallel for 110 v. The sketch shows the wiring in detail.

Cold Spring, Minn. CHAS. A. PETERSON.

AT A TIME when labor turnover is one of the major problems of industrial management, the experience of the Pickering Governor Co. of Portland, Conn., presents a unique record. Recent check of their employs shows that the average length of time they have been with the company is 27½ yr. This figure includes executives, office workers and shop force. Over 50 per cent of Pickering employes have never had any other job, having started with the company as youngsters.

In commenting on this unusual showing, George C. Pascall, secretary, said, "The exacting precision with which our governors are made requires a technical skill on the part of our workmen of a high order, which can be gained only by long experience. Since the founding of our company nearly 70 yr. ago, we have pursued the policy of selecting employes with extreme care and then doing everything in our power to make them feel they are a permanent part of our organization. The result is that labor turnover has never been a problem with us. Our men take a keen personal pride and interest in their work and in the quality standards that we have established for our governors."

Editorial Comment

Ten Years of Progress

As in previous years, this, the last issue of the year is devoted to a review of the year's progress in power plant engineering. In it we have attempted to record the important achievements of the year and from that standpoint alone it should be of interest, for, despite the fact that it has been a year of comparative quiet as regards new construction, there has been considerable development along purely technical lines.

Aside from this, however, this issue of Power Plant Engineering has another interest for it marks the end of ten years and gives us some idea of the progress that has been made in a decade. And what a decade it has been! What tremendous changes there have been since 1920! The power plant industry is growing up. Let us pause and consider what we didn't have in those days when it was believed that turbines had about reached their limit of capacity.

Ten years ago, an air preheater was merely a subject for interesting speculation, there were no such things and stage heating might have been a term associated with theaters. The regenerative cycle was still to come into prominence. Water walls were confined only to Scotch boilers and were not spoken of as such; reheat was a term that held little or no significance. A 35,000-kw. turbine was big and it was rumored they could not be made much larger because of the limitations on the physical size of equipment imposed by the railroad clearances.

Pulverized coal was still an "experiment" ten years ago, to be seen on a commercial scale only at Oneida St. Station in Milwaukee and a contemplated 400 lb. steam pressure was talked of in whispers. Slag tap furnaces, radiant superheaters, steaming economizers, turbulent burners, central and unit systems, ash sluicing, were terms not in the power plant dictionary. In the field of feedwater treatment "caustic embrittlement," was not even suspected while "sulphate-carbonate" ratio was thought to be a product of the soda fountain rather than having anything to do with boilers. Combustion generators remained to be born.

In electrical engineering no one had ever heard of "isolated phase" ten years ago. Tap changing, load ratio control, conservators held as little meaning in connection with transformers as did iron clad switchgear with switchboards. There was some talk about the possibility of a 33,000-v. underground cable but its success was a matter of speculation and several years remained before the construction of such a cable would be attempted.

Vacuum tubes and photo cells were known only in the scientific laboratories and to a few "wireless" enthusiasts, who spoke of them as audions. And that famous Greco-Schenectady "Tron" family still had to make its appearance. Perhaps "Radiotron" the father of this family was in existence—our memory fails us, but certainly, the children, Kenotron, Magnetron, Dynatron, Pliotron and Thyratron were yet to be born.

A great decade, indeed. But these are not all the things that were unknown in 1920. Carrier current for instance had never entered a power station; it, also was known to only a few radio men who called it "wired wireless." Automatic substations were used only in the railway field, while supervisory control remained to be invented. Two hundred and twenty thousand-volt transmission was something that had been talked about but its realization was still several years in the future.

One wonders what we found to write about, with all of these things out of our technical vocabulary and, in looking back over some of the old issues, we find that engineering was quite simple in comparison to what it is today. But though modern principles and equipment were lacking, we find the pages dominated by the same spirit which rules them today, a spirit of progress and everlasting effort towards a greater future. We can look back with justifiable pride on the past ten years and the part we have played in their development. Let us hope that the next decade will be equally fruitful.

Use of Models in Hydraulic Practice

It has long been recognized that small models can be used successfully in pre-determining the performance of full sized equipment in many fields. The ship building industry, for instance, has made use of small models for many years, and scarcely any ship of consequence was constructed until a small model of it had first been made and tested. Models have been used also in other fields—in the electrical industry, models of transmission systems are set up to indicate the characteristics of contemplated systems and a method has been worked out whereby small models of antennas can be used to predict the radiating characteristics of large antennas—but in no field have models been more useful than in hydraulics; first in connection with the design of ships and more recently with the design of hydro-electric developments.

An essential factor in the use of models is the so-called factor of similitude. In the design of a radio antenna, it is not alone sufficient to reduce the physical dimensions of a contemplated radiating system to a small scale, but the frequency of the currents used with the model also must undergo a change so that the performance of the model will bear a certain definite relation to the performance of its full size counterpart. If the physical dimensions of the antenna are reduced say 100 times, the frequency of the current used with the model must be 100 times the frequency of the large system. This factor of similitude is one that often is not considered and probably accounts for the lack of a more general application of models in other fields.

In the hydraulic field, this factor seems to have received its proper consideration as is evidenced by the great success in the use of models. As reported in one

article by Byron White in this issue, at Karlsruhe, Germany, it has been found possible to make reliable accelerated cavitation tests by the use of light metals and fractional heads correctly duplicating results found with full heads and full-size homologous machines.

At Spier Falls, N. Y., experiments with a small scale model of the forebay and conduits resulted in a large saving in construction costs and in the "down time" of the old plant during its enlargement.

These are only two of many instances in the hydraulic field where models have proved of great benefit and it is encouraging to note that a greater interest is being taken in models generally. Many universities throughout the country are increasing their hydraulic laboratory facilities and in many of these, the use of models is receiving considerable attention.

Whenever, solid matter acts or is acted upon by fluids, models can be used to advantage and with some of the more modern methods developed for arresting motion, it is possible not only to study the integrated effect of these fluids but also their instantaneous action. By means of the recently developed mean-lamp stroboscope, for instance, it was possible to see exactly how the water was thrown off from the edges of an airplane propeller whirling in the rain. In the light of the neon stroboscope, the whirling propeller blades appeared stationary and the erosive action of the water could be seen plainly. As a result of this study the propeller blade was redesigned so as to prevent this erosive action.

A similar use of this stroboscope, no doubt, could be made in connection with model tests of hydraulic turbine runners, with a view toward improving both their efficiency and life. We offer the suggestion for what it is worth.

A Flag or a Chain?

From present indications, it is evident that atmospheric pollution by solid matter and noxious gases from boiler plants is a subject of importance which will have to be mastered in the near future. Pollution by solid matter, that is fly ash and carbon particles, has been recognized for a number of years but pollution by noxious or injurious gases is an angle upon which the spotlight has been turned but recently.

In the Battersea (London) Station controversy, some considerable surprise has been occasioned by the relative unimportance attached to the dust or ash particles and the importance attached to sulphur fumes. In this country attention has been focused upon the matter by at least one city ordinance aimed at noxious and injurious gases, even though this ordinance does not attempt or even suggest a solution.

True, boiler plants have not been singled out for individual attention and it is apparent that the problem of certain industrial furnaces and processes should be of more immediate interest to municipal authorities.

Contrary to current opinion, the sulphur problem of power plants is not analogous to the sulphur problem of copper smelters where sulphur fumes have laid waste entire countrysides and the concentration is such that its effects are felt for distances of 10 or 15 mi. Furthermore, although vegetation is affected by these fumes, human beings apparently are not and in industrial communities the need for protecting vegetation is not of prime importance. At any rate, with the sulphur gas concentration prevailing around a power plant, it is probable that the precipitation of fine dust will be equally, if not more, detrimental than the gas to vegetation and decidedly more injurious to human beings.

Elimination of dust has been attacked quite successfully by electrostatic precipitators, centrifugal devices, sprays, bag filters and other mechanical devices. Tests from bag filters indicate that somewhat over 90 per cent of the solids collected from a pulverized coal unit will pass through a 325 mesh screen. When it is considered that a 325-mesh screen looks like a fine piece of cloth and will hold water, the difficulties of removing these small particles becomes more apparent.

Attention to gas pollution brings up further complications. Should the gas and dust be removed in one step or should the dust be removed first? If the dust is removed first, should it be collected and handled wet or dry? If handed wet, will the additional cost of fighting corrosion be excessive?

Sprays have been used to a limited extent for the elimination of both dust and gas in a single step. The amount of gas removed is, however, open to debate. Sulphur exists in the gases principally as SO_2 with a small percentage of SO_3. The latter is highly soluble and, under usual conditions, the former is quite soluble in water. It is not, however, soluble enough to be taken up appreciably by a spray, with gases moving at from 600 to 1200 ft. per min.

Data from the Battersea report states that, to dissolve 90 per cent of the sulphur in the flue gas from coal containing 36 per cent sulphur, it is necessary to use about 13 t. of water per ton of coal burned. More important, the gases have to be in contact with the water 9 sec., an impossible length of time for power plants. By using hot water at 145 deg. F., the SO_2 can be converted to SO_3 and the amount of water reduced. The above figures correspond roughly to 1 gal. for every 175 cu. ft. of gas. With low sulphur content one gallon can be made to take care of up to 400 cu. ft. For dust removal, one gallon of water will take care of from 400 to 4000 cu. ft. of gases, so that when both gas and dust are to be removed gas removal is the factor determining the water requirements. In other words, with sprays the dust will be taken care of, if the gases are successfully dealt with.

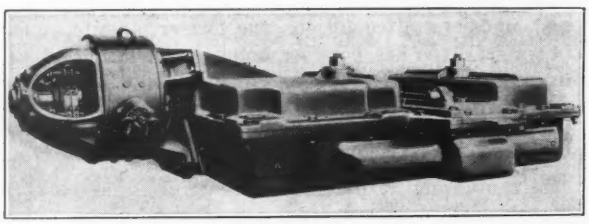
Gases must also leave the washer at comparatively low temperature in order to avoid precipitation of water when cooled to atmospheric temperature after leaving the stack. The spray water used is also a problem. If it is recirculated because water supply is limited, it must be neutralized. It also carries considerable gritty dust which is highly abrasive to pipes, pumps and sprays. If water is unlimited, its acid condition causes difficulties. In at least one case, the pollution of the atmosphere was of less consequence than stream pollution due to the acid spray water.

Some progress has been made but it is still a problem of major importance to the industry. Although by no means the worst offenders, the burden of solving this problem lies with the public utilities. Public opinion, agitated by those interested for political reasons will eventually force legislation. Public relations considerations dictate that the utilities finance capable research along this line and solve the problems of their own accord, before being forced to it by popular demand. It is better to precede the band wagon waving a flag than it is to be dragged behind it by a chain.

Power Plant Engineering Developments and News

Shaker Conveyor Drive

EFFICIENT shaker conveyor drives have always been quite a troublesome problem, largely because of the difficulty of securing the proper relation between acceleration and retardation. In the new drive developed by the Conveyor Sales Co., Inc., of New York City is applied a new principle. This is primarily built for use in coal mines, but is useful for sand and gravel,



MOTOR DRIVE FOR SHAKER CONVEYORS

power houses, or any industrial plant where bulk granular material is to be conveyed for comparatively short distances. Its compactness, height 25 in., width 85 in., plus from 21 to 36 in. for the motor, and length 44 in., with weight 6400 lb. fit it for installation in limited space.

The mechanism consists of a gear train and cross arm which convert the rotary motion of the motor into reciprocating motion of a crosshead that is connected to the conveyor trough. The mechanism is totally enclosed in a heavy cast-steel case, which also serves as an oil reservoir, and is provided with three separate covers, giving easy access to any part. Four sockets are cast into the top of the case for the reception of ratchet holding jacks and, since the drive straddles the conveyor, no twisting strains are put upon the jacks to loosen them. The 20-hp. driving motor is bracket mounted by pads cast integral with the case and may be either d.c. or a.c., enclosed or open, as required. Automatic remote control with time limit acceleration and full protection against overload and under voltage are provided.

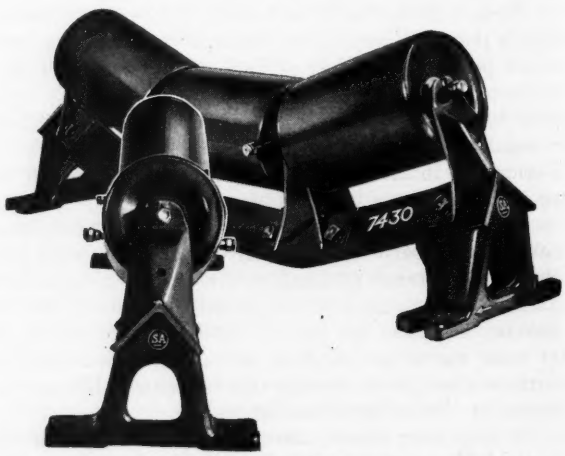
Gears are made from heat-treated cast steel with stub cut teeth, and all shafts are mounted in Timken bearings, the mountings being such as to hold the various shafts in rigid alinement. The whole bottom of the case serves as a reservoir for lubricant, lubrication of the various bearings being provided by an oil pump, located in the case and driven by an eccentric machined on the primary drive shaft.

Since rotary motion of the gears is transposed into reciprocating motion of the crosshead by the action of a crossarm working on wristpins in the gears, the peak velocity of the forward stroke comes beyond 120 deg. of the full revolution, and the peak of the reverse, or retarding stroke before 240 deg. Consequently, there is no waste of power and no tendency for retrograde slipping of the material in the trough. Maximum length of the stroke is 11 in., but it is possible to adjust this quite simply, by altering the angular relation of the wristpin and shaft on one gear with that of the wristpin and shaft on the other. Altogether 14 different strokes, between 11 in. and zero are available for any setting of the drive, that is whether it is running right or left-handed with respect to the placing of the motor side to the conveyor trough.

Roller Bearing Belt Conveyor

FOR USE where high grade equipment of medium price is desired, Stephens-Adamson Mfg. Co., Aurora, Ill., has developed its Pacific Type roller bearing belt conveyor.

As shown, this has three rollers, giving 20-deg. trough design, carried on a cross member of heavy struc-



PACIFIC TYPE BELT CONVEYOR CARRIER

tural steel. Bearing brackets are of heavy pressed steel, all of the same design and interchangeable for all sizes of conveyors. Only the end stands are castings.

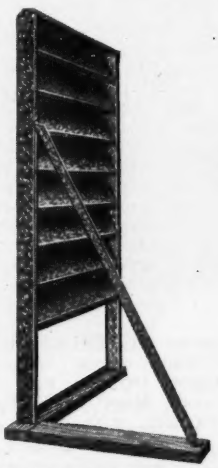
Each roller has an inner hub of steel tubing, extending the full length of the roller and housing at each end a Timken tapered roller bearing, of large size, which carries end thrust as well as radial loads. Special provision is made for adjusting bearings for proper clearance, also for individual Alemite lubrication at each bearing, giving a grease seal against dust and moisture.

This makes each roller a self-contained unit, so that, with its shaft and bearings it can be easily interchanged with any other roller without disturbing bearing adjustment.

The Pacific carrier is built in sizes for belts from 18 to 48 in. wide and with dimensions such as clearance, bolt spacing and over-all size practically the same as for other types of the company's manufacture.

Steel Louver Fencing

ONE OF THE details of cooling pond construction is the louver fence for preventing driftage losses. A metal fence of this type, made up of galvanized steel standard sections 5 ft. wide and in different heights from 9 to 14 ft. depending on the service, has recently been placed on the market by Binks Manufacturing Co., 3114 Carroll Ave., Chicago, Ill. These fences are furnished complete and ready for installation. They have galvanized angle iron braces, frame of 16 gage galvanized material and 18 gage louver plates riveted in place. A series of holes is provided on each side of the frame so that the louvers may be installed on a gently sloping roof. They are designed to be erected on the job by ordinary labor. Narrow sections of 2 to 4 ft. wide are also made for use where conditions demand them. Galvanized corner angles are supplied with each installation.

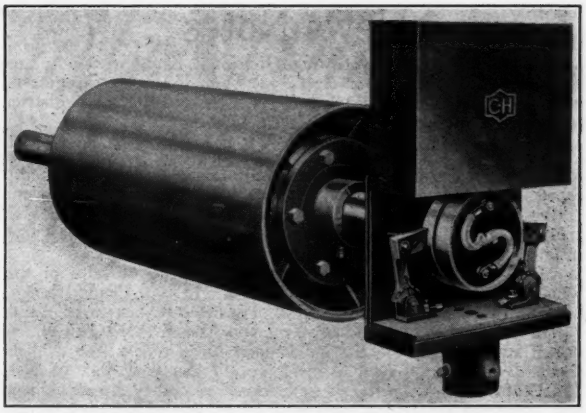


STANDARD SECTION OF STEEL LOUVER FENCING

Magnetic Separator Pulley

DESIGNED for simple construction, long wearing qualities and low price the new type W magnetic separator pulley is announced by Cutler-Hammer, Inc., 191 12th St., Milwaukee, Wis. The new pulley has three major parts a machined cast-steel spool, the magnet coils and a coil shield, with the necessary insulation. The magnet coils are wound on the steel spool and vacuum impregnated to make them moisture proof. The coil shield is then welded to the spool so that it completely encloses the coils. This coil shield is of Allegheny metal to provide a tough, long wearing, nonmagnetic pulley surface.

The commutating mechanism, which conducts the current to the magnet coils, is mounted on one end of the pulley shaft. Heavy brass collector rings and carbon brushes are used to assure good contact at all times. A dust-proof cover is employed to protect the commutating mechanism from dust and other flying particles and to protect operators from accidental contact with live parts.



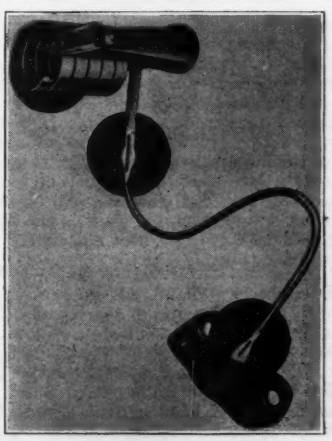
MAGNETIC SEPARATOR PULLEY AND ITS COMMUTATING MECHANISM

These pulleys are made 12 in. in diameter and in six lengths for belt widths varying from 12 to 30 in.

Steel Spring Recording Gages

DURING THE current year an alloy-steel helical spring movement for its recording gages has been developed by Foxboro Co. of Foxboro, Mass. This new movement is of one-piece tubing—all steel and all welded. It is designed to combine maximum safety with high resistance to commonly encountered corrosive agents. One of these new alloy-steel helical movements is illustrated below.

The alloy-steel movements may be specified with all new Foxboro recording gages or may be ordered separate to be installed in old Foxboro recording gages now in operation. The new movements are built for use with gas, water, steam, oil, air, brine, chemicals, where the pressures do not exceed 2000 lb. per sq. in.



FOXBORO ALL-STEEL CONSTRUCTION INCLUDES THREE WELDED JOINTS

News Notes

WICKES BOILER Co. (Heating Division), Saginaw, Mich., announces the appointment of H. E. Jacobsen, Room 200, Engineering Building, 205 West Wacker Drive, Chicago, Ill., as its district representative, effective November 20, 1930.

FOLLOWING a special meeting of the board of directors of the Reading Iron Co. in Philadelphia, A. J. Maloney, chairman of the board, announced the election of P. N. Guthrie, Jr., as president of the Reading Iron Co. Mr. Guthrie has been serving as vice president, in charge of sales. He succeeds Leon E. Thomas who resigned the presidency on July 31, 1930.

Mr. Guthrie became vice president in charge of sales of the Reading Iron Co. on December 1, 1929. He is a Pennsylvanian, born in Pittsburgh, April 26, 1876. He received his initial training in the employ of Park Brothers and Co. of Pittsburgh which owned and operated the Black Diamond Steel Works, the nucleus around which the Crucible Steel Co. of America was formed. Mr. Guthrie has had extensive experience also in the management and operation of natural gas utilities in Western Pennsylvania, West Virginia, Kentucky, Tennessee and Southern New York.

Mr. Guthrie served for several years as sales agent and general manager of sales for the Long Mead Iron Co. In 1909 he took charge of sales for the South Chester Tube Co. of Chester, Pa., in a large territory which included most of the oil fields in

P. N. GUTHRIE, JR.

this country. In July, 1917, Mr. Guthrie left the South Chester Tube Co. on leave of absence and entered the Government Service as Assistant Director, Bureau of Oil Well Supplies, Oil Division, U. S. Fuel Administration. At the end of the war he returned to the South Chester Tube Co. and in February, 1919, was made manager of sales, serving in this capacity until his resignation in December, 1929, to become vice president in charge of sales of the Reading Iron Co.

RAY SCOGGINS has taken the position of manager of Sales Engineering Co., 3326 White-Henry-Stuart Bldg., Seattle, Wash., handling the business of Clarage Fan Co. and Terry Steam Turbine Co. in the northwest. Previously, Mr. Scoggins has been, for 3 yr., assistant engineer for Byllesby Eng'g and Management Corpn. at Marshfield, Ore., resigning to take up his present work.

GENERAL ELECTRIC Co. has awarded the George A. Fuller Co. of New York the contract to construct the new transformer tank manufacturing building at Pittsfield, it was announced by E. A. Wagner, general manager. Construction will start at once and it is expected to have the building completed early in the spring. Unusual methods of construction will be employed. There will be no masonry as such. Nothing but concrete and steel will be used. Instead of the customary brick pilasters to support the roof girders, electrically welded steel supports will be used. The building will have walls of steel and glass and will be one of the best-lighted manufacturing units in the plant. The building, which will cost about $1,000,000, will be used exclusively for the manufacture of transformer tanks.

EFFECTIVE December 1, 1930, A. M. Cullum resigned his position as oil country sales manager of the Reading Iron Co., with headquarters at Tulsa, Okla. He will take up a position with the Harbison Walker Refractories Co., Pittsburgh. In addition to his duties as advertising manager, manager of cut nail sales and manager of sales for the Stoyestown Coal Mine, a soft coal property owned and operated by the Reading Iron Co., R. W. Thompson has been appointed director of public relations. Harold S. Bard has been appointed district sales representative of the Reading Iron Co. with offices at 1714 Engineering Bldg., Chicago, Ill. Mr. Bard succeeds R. A. Griffin, resigned.

DAMPNEY COMPANY OF AMERICA, Hyde Park, Boston, Mass., announces the opening of a direct company branch office to serve the Middle West Territory. The address is Monadnock Block, 53 West Jackson Blvd., Chicago, Ill. R. G. Ingram, J. D. Bird and C. M. Boling will have their headquarters in Chicago.

WILLIAM G. CHRISTY, mechanical engineer of the Board of Education of St. Louis, has been appointed Engineer in charge of the newly organized Smoke Abatement Bureau of Hudson County, New Jersey. The Smoke Abatement Bureau will be a new department of the Board of Health of Hudson County. This smoke campaign will be conducted in coöperation with Stevens Institute of Technology at Hoboken, where Colonel Elliott H. Whitlock, for the past six years Smoke Commissioner of Cleveland, Ohio, has been appointed to the chair of Smoke Abatement Research. Whitlock will coördinate all smoke activities in various counties and municipalities of New York, New Jersey and Connecticut with the smoke abatement campaign in New York City. Hudson County is appropriating $40,000.00 for the first year's work.

RICHARD WOODS EDMONDS, formerly of the editorial staff of Manufacturers Record, is now associated with Korbel & Colwell, Inc., 441 Lexington Avenue, New York. He will specialize in booklets and copy dealing with industrial and engineering matters.

HUCKINS HOTEL, Oklahoma City, Okla., is making a few important changes in the operation of its old power plant. It is adding to the old power plant one Chuse engine manufactured by the Mattoon Engine Works. This is a 325-kw. direct, coupled to a Crocker-Wheeler d.c. generator. The installing will be done by the engine manufacturer. This also entails an enlargement of the switchboard by an additional panel to take care of this extra equipment, this panel is manufactured by Wourdauck Mfg. Co. The connected load then will total 725 kw. This change will total an expenditure when complete of $30,000.00 and the equipment will be ready for operation about January 15. This unit has been added as the demand was slowly increasing and it was necessary to take care of future requirements. It will anticipate the needs for the next five years. Marquand Huckins is manager and J. J. Bevan is chief engineer of the Huckins Hotel.

MODERN COAL BURNER Co., 3733 Lincoln Ave., Chicago, Ill., has opened two new branch offices. Harvey T. Wharton is in charge of the Minneapolis territory, with offices located at 720 Baker Bldg., Minneapolis, Minn. L. E. Beckwith is in charge of the Davenport territory, with offices at 509 Kahl Bldg., Davenport, Ia.

STERLING ENGINE Co. of Buffalo, N. Y., has opened a New York City office to dispense information and for the convenience of New York clients. William Edgar John is the manager of this office, which is located at 900 Chrysler Bldg.

AT A SPECIAL ELECTION, November 18, voters of Oklahoma City granted to the Oklahoma Gas and Electric Co., a renewal of the company's franchise. The franchise gives the Oklahoma Gas and Electric Co. the right to own, direct, maintain, extend and operate lines for the purpose of transmitting and distributing electric current for lighting, heating, power and other purposes in Oklahoma City and for the purpose of selling and distributing electric current to the city and the public generally for a period of 25 yr.

CONDENSED STATEMENT of operations of Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., is given as follows:

	Nine Months Ended Septemebr 30		
	1930	1929	1928
Orders Received	$132,715,293	$185,625,135	$143,637,037
Sales Billed	137,446,908	159,545,778	138,572,390
Net Income after Depreciation, Reserves and Taxes	11,355,619	19,796,819	15,425,424
Interest Charges	3,375	252,608	1,135,389
Balance Available	*11,352,244	19,544,211	14,290,035

*Equal to $4.25 per share on the Outstanding Preferred and Common Stocks.

Orders received and sales billed this year do not include radio receiving sets and tubes, the manufacture of which was transferred as of January 1, 1930, to the Radio Corporation of America. The income from sales of receiving sets and tubes now being distributed under the Westinghouse name will be included in net income. For products other than radio, orders received during the 9 mo. period of 1930, compared with the corresponding periods of 1929 and 1928, show a decrease of 17 per cent from 1929 and an increase of 8 per cent over 1928.

Characteristically Elliott **motor-generator** *service pleases this chemical plant...*

Three Elliott 1120-kw. motor-generator sets installed in a chemical plant in the middle west for electrolytic service.

The unusually good service obtained from three Elliott generating units installed fifteen or twenty years ago sold the first of the above sets, which upon installation was operated without shutdown for many months. The other two sets were later installed due to the excellent service of the first.

The chemical plant is particularly impressed with the high overall efficiency of Elliott motor-generators and the distributed compensated winding of the generators which gives good commutation at all loads. These sets have been operating under particularly bad conditions due to chemically contaminated air.

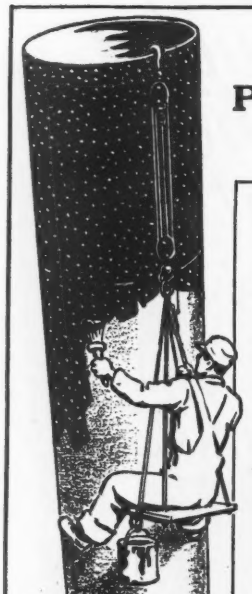
Elliott motor-generators are in service in plants of all kinds, handling difficult fluctuating loads without trouble; steady loads at excellent efficiency; fractional loads at maximum economy—meaning savings in power cost; always operating smoothly, and with unexcelled commutation.

Elliott motor-generators have the stuff in them.

ELLIOTT COMPANY
PITTSBURGH, PA.
Electric Power Dept. - - RIDGWAY, PA.
Branch Offices in Principal Cities

Elliott Power Equipment includes engines and turbines, generators, motors and electrical machinery, condensers, deaerators, heaters, centrifugal blowers and accessory equipment.

O-937



How do *Your* Protective Paints "Stack Up"?

Not only on stacks but on all other exposed steel work, on cooling towers, on boiler fronts, on surfaces indoors and out — especially where there is high temperature, high humidity or a prevalence of chemical fumes—

BITUMASTIC SOLUTION

—will not only "stack up" favorably with other paints but will long outlast them. In many cases, this brilliant, black, quick drying, heat resisting and impervious bituminous paint is the only coating which has ever offered any degree of permanent protection. Apply it to the surfaces which require repainting most frequently and see how largely your repainting costs can be reduced.

Write for Bulletin 265-A

BITUMASTIC REG. U.S. PAT. OFF.

SOLUTION

WAILES DOVE-HERMISTON CORPORATION
17 Battery Place, New York
Philadelphia Cleveland Chicago Tulsa Houston San Francisco Los Angeles
Agents in Principal Cities

Specify The Complete

Estab. 43 yrs.

Let our experienced engineers furnish your plant with packings that give satisfaction and meet all requirements. Write for our new book.

CRANDALL

CRANDALL PACKING CO.
Main Office and Factory
Palmyra, N. Y.

Packing Service

BRANCHES:
New York Birmingham
Chicago Pittsburgh
Philadelphia Cleveland
St. Louis Boston
Kansas City Oakland, Calif.
Montreal, Canada

DARCOID Discs will not soften or wear unevenly

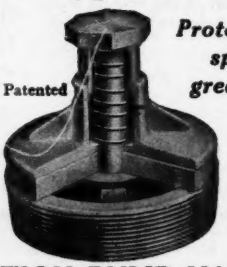
These discs stand up under hot or cold water; steam, all pressures; gas, oil, acids, chemicals and air for use on any standard make of valves. Write for full details and sample of this long-service packing.

THE DARCOID COMPANY
Incorporated
P. O. Box 209, City Hall Station, New York City

The Standard Type Valve Assembly

Construction insures a straight lift

Patented



Protected bronze springs insure great durability and efficiency

Increases life of valve disc

Write today for descriptive circular

COMBINATION PUMP VALVE CO.
Established 1915
Main Office and Factory, 846 Wiota St., Philadelphia, Pa.

RESISTANT RESILIENT

Write for folder

Armor-Clad "Flexitallic" Gasket

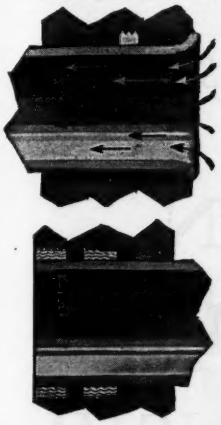
Meeting the demands of modern plant service, "Flexitallic" Armor-Clad Gaskets easily resist rust, acid and high superheat. Tested to 9000 lb. per sq. in. pressure. Write for folder of facts.

"Flexitallic" Gasket Company
Main Office and Factory: Camden, New Jersey

In Repacking Condenser Tubes

--here's genuine economy and increased efficiency

The first economy is in the cost of ferrules. The ferrule is no longer necessary with the "John Crane" process. The next saving is in speed of installation —one man packs 150 tube ends per hour with "John Crane" Packing.



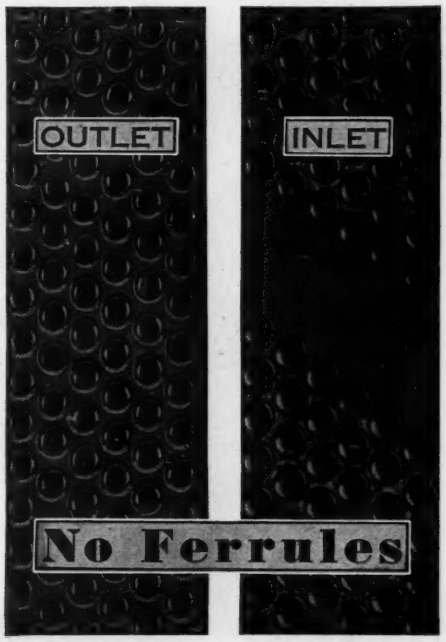
The greatest saving, however, is in service. Tubes expand freely, eliminating stresses on tubes and tube sheets. Turbulence caused by ferrules is eliminated. Flow lines are unimpeded. Collection of debris at inflow ends is reduced.

The endless metallic rings on the outflow and the lead insert in the bushing at the inflow end provide metallic bond, thus reducing electrolytic disintegration of tube ends. Tubes are easier to clean when ferrules have been eliminated. The packing is non-deteriorating—unaffected by heat or by impurities in cooling waters.

These are reasons why hundreds of plants, including the largest ones, are using the "John Crane" Process in both repacking and new installations. Recommendations and estimates furnished gladly.

CRANE PACKING COMPANY

1802 Cuyler Ave., Chicago — 21 Bridge Street, New York
112 Ninth St., San Francisco — Dime Bank Bldg., Detroit
108 Walnut St. Philadelphia — 99 Vandergrift Bldg., Pittsburgh



"John Crane"

Metallic Condenser Packing

Look for the Trade Mark on Each Box

METALLO—the gasket that seals tight and *stays tight!*

Write for 32-page booklet free

Economy in gaskets means the gaskets that give TIGHT service for the longest time at the least cost per unit of time.

Metallo Gaskets represent long experience, advance engineering design and the highest manufacturing standards in producing gaskets that will insure the lowest possible costs per year of service.

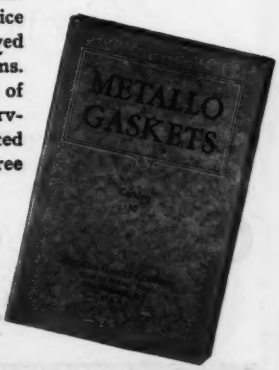
It pays to buy only the best, in gaskets particularly, whether the price be high, low or medium.

Metallo Gaskets and Valve Discs come in a complete line for every type of service in power plants, oil refineries and other industries where media is piped. Each type is specially constructed for its own particular service and actual service records have proved their performance exceeds our claims.

Write for Metallo Booklet — full of valuable information. For steam service you will be particularly interested in Style 2 Gasket and our 90-day free trial offer.

At left, sectional view of Style 2 Gasket, showing corrugations of metal, suitable for the service, each corrugation interlaid with asbestos cord.

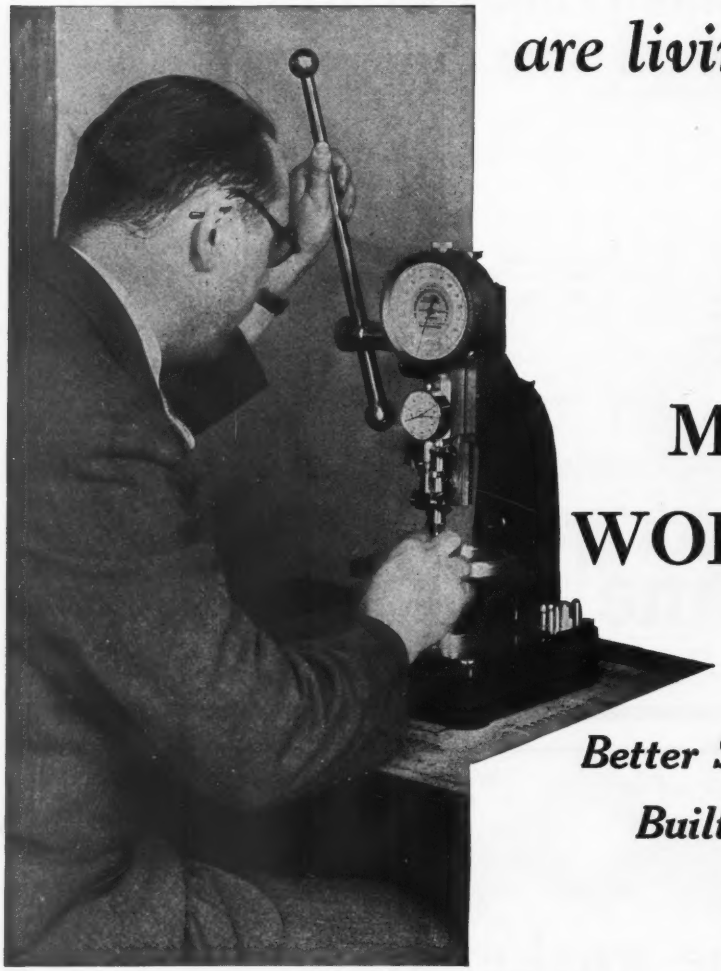
Trial Gasket Sent Free



METALLO Gasket Co.

New Brunswick, New Jersey

GOETZE GASKETS



are living up to the

3 *essentials*

DESIGN
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WORKMANSHIP

Better Service
Built by Continuous
Scientific Watchfulness

Our Standard Products are—

No. 1 Plain Corrugated Metal
No. 2 Corrugated Metal with Asbestos
No. 3 Corrugated Metal Asbestos with Graphite Cement
Triumph Type—Metal Shell—Asbestos
(*a*) *Single Jacketed*, (*b*) *Double Jacketed*
French Type
Inside Open Type
Cylinder Head Gaskets
No. 1200 Type Metal Asbestos
Seamless Solid Rings
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Boiler Gaskets for Handholes, Manholes and Tube Caps
Lead Gaskets
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GOETZE PACKINGS FOR STUFFING BOXES
Flexible Metallic Packing, Rex Metallic Packing, Braided Asbestos Packing
Special Packings and Gaskets
Stampings

Goetze Gasket & Packing Co., Inc.

17 Allen Ave., New Brunswick, N. J.

Leaks are Losses

Seal Joints with KEY GRAPHITE PASTE

IT TAKES more than an ordinary sealer to make perfect joints in Oil, High Pressure Steam and Acid lines. If you are to avoid the waste caused by leaks, make a trial of the one compound that always seals 100% tight: Key Graphite Paste.

Sending the coupon below has been the first step toward ending leaks for hundreds of firms in many diverse industries. It will be the beginning of an economy for you.

Instead of sealing for a time only, Key Graphite Paste makes every joint leak-proof as long as you like. Even high temperatures or constant vibration do not break its seal. It never allows rust or corrosion, keeps threads in good condition, so that when necessary the connection can be broken easily. Its lubrication speeds the making up of pipe joints and its greater ease of use is emphasized by the fact that water alone is required to thin it. But prove these merits on your own jobs—send the coupon.

Listed by the National Board of Fire Underwriters.

FREE TEST SUPPLY

PPE 12-15-30

Key Boiler Equipment Co.
East St. Louis, Ill.
Please send me a free test supply of Key Graphite Paste.

Company .....

Address .....

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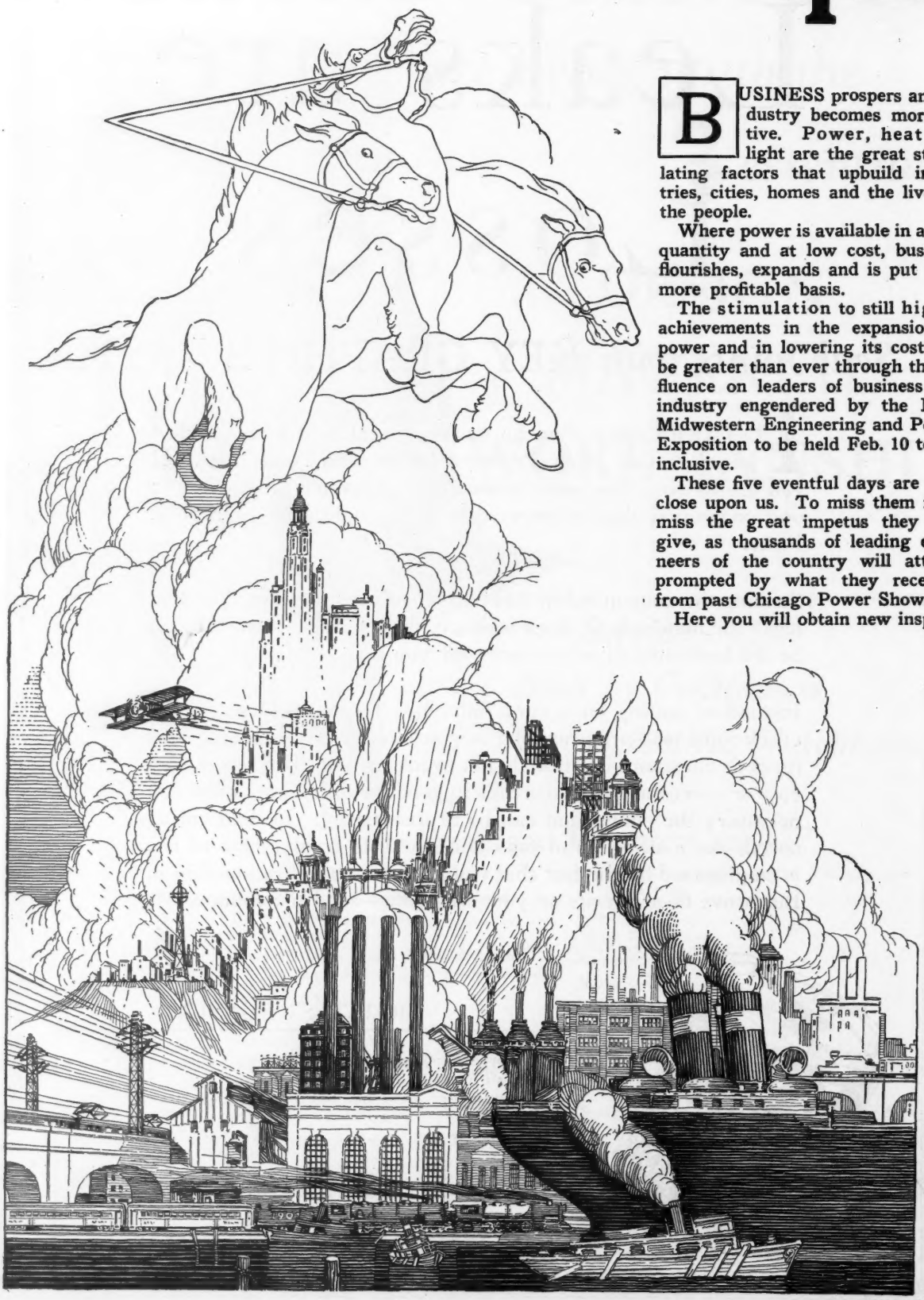

BUSINESS prospers and industry becomes more active. Power, heat and light are the great stimulating factors that upbuild industries, cities, homes and the lives of the people.

Where power is available in ample quantity and at low cost, business flourishes, expands and is put on a more profitable basis.

The stimulation to still higher achievements in the expansion of power and in lowering its cost will be greater than ever through the influence on leaders of business and industry engendered by the Fifth Midwestern Engineering and Power Exposition to be held Feb. 10 to 14, inclusive.

These five eventful days are now close upon us. To miss them is to miss the great impetus they will give, as thousands of leading engineers of the country will attend, prompted by what they received from past Chicago Power Shows.

Here you will obtain new inspira-

GREAT EXPOSITION WILL HELP YOU

tion, new ideas, new contacts and valuable information that will start off the year in the right way and see it end with a higher professional standing, more profitable operation of plants and increased authority that is bound to come to every man with the genius and knowledge to exercise it!

Not only to the designing, constructing and operating engineers of the country, but to financiers and heads of leading industries of all kinds, will this Show bring a message of great immediate help and future potentiality.

New equipment, new methods, new standards of operation will be shown here. The contacts made and the information secured will surely put power on a higher standard of efficiency.

Meetings of importance include the 5th Midwest Power Engineering Conference and 4th National Fuels Meeting of the A.S.M.E. Discussions of live power subjects will help everyone attending to keep abreast of the times; to hear of the advances in the art and to meet those masters of Power whose words have great meaning in a gathering such as this.

Join with your fellow leaders in the Power Industry by setting aside the time now to attend this great educational Exposition. Words fail in describing the scope and attractiveness of the many exhibits available. By seeing only can you realize this great opportunity.

MIDWESTERN ENGINEERING EXPOSITION, INC., 308 W. WASHINGTON ST., CHICAGO

SOME OF THE MANY EXHIBITORS:

Ahlberg Bearing Co.
Allis-Chalmers Mfg. Co.
American Brass Co.
Armstrong Machine Works
Appleton Electric Company
Bailey Meter Co.
Babcock & Wilcox
Badger & Sons Co., E. B.
Bartlett-Hayward Co.
Breuer Electric Mfg. Co.
Buffalo Forge Company
Carborundum Company
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Cleveland Worm & Gear Co.
Combustioneer, Inc.
Combustion Engineering Corp.
Detrick Co., M. H.
Diamond Power Specialty Corp.
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Riley Stoker Corporation
SKF Industries, Inc.
Standard Oil Company
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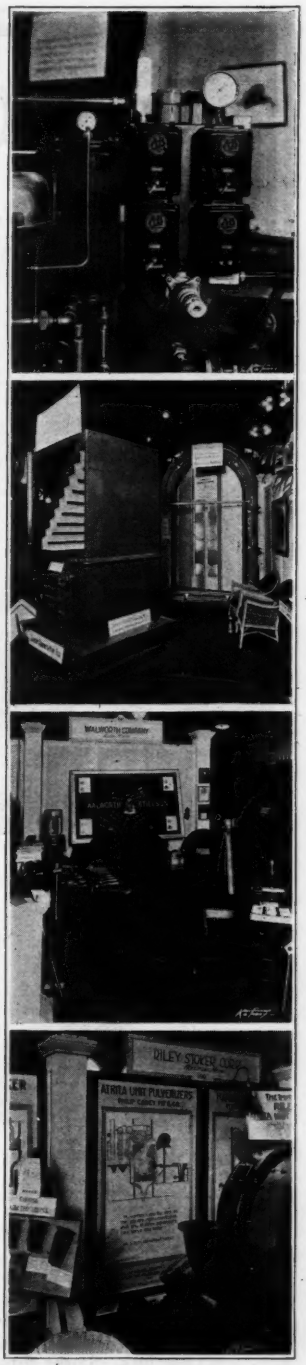


Meet with the Masters of Power at the

Chicago Power Show

Coliseum February 10 to 14 INC.

DIXON'S
GRAPHITE PRODUCTS

The best graphite procurable—the right graphite for each particular purpose—scientific manufacturing methods—these are the open secret of Dixon superiority

We have had almost one hundred years of experience in manufacturing and marketing graphite—and in this period the word "Dixon" has spread around the world. To thousands of exacting men in every line of industry that word is synonymous with graphite.

Dixon's Graphite Cup Grease. The best quality mineral oils correctly proportioned with lubricating flake graphite. It has the property of flowing into the bearing as soon as the shaft begins to turn, instead of remaining stiff in the cup till the bearing heats and softens it. Produces cool smooth, graphited bearing surfaces—insures cool running engine, motor shaft and other bearings.

Dixon's Ticonderoga Flake Graphite. Ideal for cylinder and bearing lubrication, for coating gaskets, and for any other purpose where a superior graphite is desired.

Dixon's Solid Belt Dressing. A product that keeps leather belts pliable and decidedly lengthens belt life. Stops slipping instantly

Dixon's Waterproof Grease. Protects and lubricates elevator plungers, pump plungers, gears, wire rope, and other parts exposed to weather or submerged in fresh or salt water. Will not flush off.

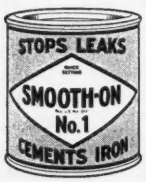
Dixon's Silica-Graphite Paint. For the protection of metal surfaces against moisture, water, acid, alkali and other rust creating agencies.

We publish an interesting booklet of over 50 pages, illustrated, containing much of value to you men of the power world. Would you like a copy? Ask for Book 94-EP

JOSEPH DIXON CRUCIBLE COMPANY
Jersey City, N. J. Established 1827

The Keystone Lubricating Co.
Executive Office and Works: Philadelphia, Pa.

Keep a supply of SMOOTH-ON handy



WITH these two grades of Smooth-On (Nos. 1 and 3) you are properly prepared to make tight new, and stop leaks in old joints, patch cracks in pressure parts, and do a perfect job with least effort.

Write for free copy of Smooth-On Repair Book.

Get Smooth-On in 1 or 5-lb. cans or larger kegs from your dealer or from us.

SMOOTH-ON MFG. CO.
Dept. 31, Jersey City, N. J.

Do it with **SMOOTH-ON**

Why be bothered with frozen locks?

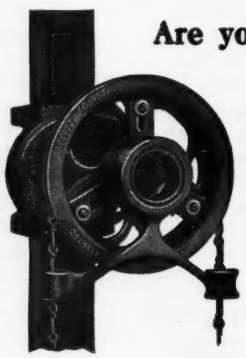
Thawing or forcing frozen locks takes more man-hours out of winter than the locks are worth—to say nothing of lengthened outages due to inoperable switches with frozen locks.

The remedy is so simple . . . water-proof the lock. Locks fitted with metal-gasketed caps, have been operated unfailingly below freezing temperatures after hours of spraying.

Standardize on its use this winter. End the cost of replacing forced locks. Stop the delay and exasperation freezing causes. The price, in such quantities as you need, is temptingly low.

Send us your locks and we will equip them —or have your new locks sent direct to us. Then you will be able to open your locks easily at any time this winter.

Associated Engineers Co.
140 South Dearborn Street
Chicago, Illinois



Are you waiting for ?

someone to break his neck before you put Babbitt Rims on your overhead valves?

Don't Wait! It's Bound to Happen If You Do!

Don't Delay! Buy Now! Safety First!

Babbitt Steam Specialty Co., Inc.
55 S. Water St.
New Bedford, Mass.

C. J. Coal Meters *keep the eyes of operators on fuel savings!*

Cannot be tampered with. Constantly indicates coal burned under each boiler. Prompts boiler operators to do their best. Easily installed on underfeed stokers with revolving shaft. Free trial.

C. J. Mfg. Co.
3427 N. 5th St.
Philadelphia, Pa.

The Story of 200 Lost Hours

TWO HUNDRED HOURS of delay . . . two hundred hours of operation lost through inadequate lubrication . . . cleaning and repairing lubrication system . . . reclaiming oil. This was the three year lubrication record of one of the giant turbines in a great manufacturing plant.*

The records further show that in two and a half years, from February 7, 1925, to July 15, 1927, two thousand, one hundred and fifteen gallons of turbine oil were used. On July 15, 1927, the lubricating system of this turbine was cleaned and Nonpareil Turbine Oil substituted for the ordinary type turbine oil formerly used.

During the next two and one-half years of operation seven hundred and forty-one gallons of Nonpareil Turbine Oil were required for lubrication . . . a saving of one thousand, three hundred and seventy-four gallons. In this period of time not one minute was required for any cleaning operation.

This record has been substantiated by similar records made with Nonpareil Turbine Oil in other plants. It demonstrates that valuable time lost through cleaning of lubrication systems is unnecessary. It shows that Nonpareil Turbine Oil can be used indefinitely without appreciable signs of sludge or acid formation. The same fill of oil, with normal amounts of makeup, can be used for years.

Your investigation of this superior turbine lubricant is welcomed.

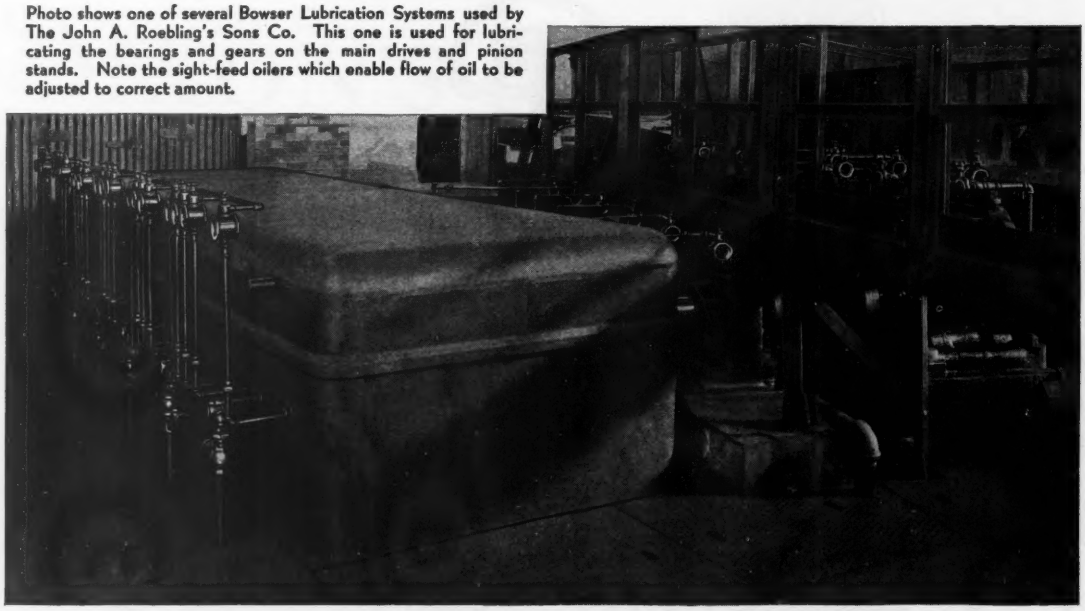
*Name on request.

1311-A

STANDARD OIL COMPANY *(Indiana)*
910 South Michigan Avenue Chicago, Illinois

NONPAREIL TURBINE OIL

Photo shows one of several Bowser Lubrication Systems used by The John A. Roebling's Sons Co. This one is used for lubricating the bearings and gears on the main drives and pinion stands. Note the sight-feed oilers which enable flow of oil to be adjusted to correct amount.



Roebling's Also Chose
BOWSER LUBRICATION SYSTEMS

BOWSER ESTABLISHED 1885

In Roebling's "Kinkora" Plant---where the mammoth wire rope cables are made---Bowser Continuous Oiling and Filtering Systems are used to efficiently lubricate the bearings and gears on all main drives, pinion stands, reelers and cross shafts in the Rod Mill---and the bearings on main reduction gear, main shaft bevel gear bearings, pinion stand bearing, cross shaft bearings and the gears in pinion stands in the Billet Mill.

These systems were engineered to meet each individual requirement to insure dependable, efficient lubrication. The systems are complete with pumps, filters, tanks, sight-feed oilers, and all auxiliary equipment, completely built, and installation supervised, by Bowser lubrication engineers.

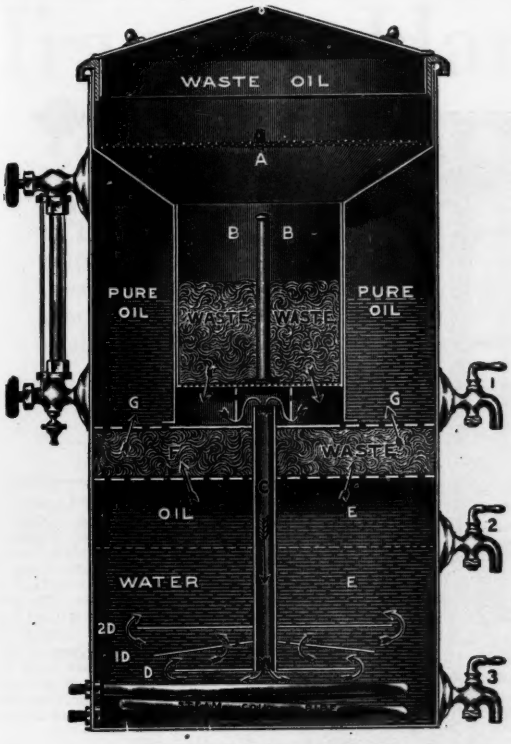
John A. Roebling's Sons Company, Trenton, N. J., in striving to effect every possible economy in the operation and maintenance of rolling mill equipment chose Bowser Lubrication Systems because of their reputation for these fundamental characteristics:

1. Prolonged service-life of costly equipment.
2. Reduced lubrication costs.
3. Minimized repair costs and shut downs.
4. Automatic, continuous delivery of clean oil to proper points, in sufficient amounts.
5. Continuous filtration of oil, restoring original lubricating value.
6. Maximum lubrication efficiency at minimum costs.

Ask any users how well their Bowser Lubrication Systems perpetuate this reputation. Consult Bowser Lubrication Engineers for complete details on any specific lubrication problem in your plant.

S. F. BOWSER & COMPANY, Inc.,
1374 CREIGHTON AVENUE * FORT WAYNE, INDIANA, U. S. A.

LUBRICATION ENGINEERS AND MANUFACTURERS



SECTIONAL VIEW
CROSS OIL FILTER

LOW PRICED and EFFICIENT

When you are thinking of some way to reduce operating costs in your plant it's a good idea to find out how much lubricating oil you are wasting by not cleaning it with a Cross Oil Filter.

This filter will save from 50 to 75 per cent of the oil ordinarily wasted and will clean every drop thoroughly so that the oil can be used over and over again in absolute safety.

The filter soon pays for itself in reclaimed oil and, when it is considered that a small size Cross costs only twenty-five dollars, no plant should be without one.

Write today for complete information or send a sample of oil for us to filter.

The BURT MFG. Co.

Ventilators-Oil Filters-Exhaust Heads

44 E. South Street Akron, Ohio

IMPROVE LUBRICATION to lower costs

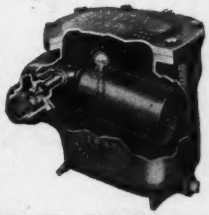
Cleaner oil offers a big chance for reducing repair and maintenance costs. In addition De Laval Oil Purifiers almost always pay for themselves by making it possible to keep the same oil in service indefinitely. Bulletin No. 106-Z.

THE DE LAVAL SEPARATOR COMPANY

New York Chicago San Francisco

DE LAVAL OIL PURIFIER

Have You Ever Seen a Steam Trap Operate with the Cover Removed?



The Valve is On the Inlet!!
No Steam Blowing!!
Non-Air Binding!!

Think what Effect this trap has on:
Your Maintenance Expense!!
Your Inspection Expense!!
Your Coal Pile!!
Your Yearly Earnings!!

Write for complete information about this trap and the K-Master Inverted Bucket Steam Trap.

Kaye & MacDonald, Inc.

Formerly K. & M. Steam Engineering Co.
96 Franklin Ave.
West Orange, N. J.
Representatives in Principal Cities.

K-MASTER
TRADE MARK

NUGENT

Manufacturers of

Oil Filters (Gravity) up to 2000 gals. per hour
Oil Filters (Pressure) up to 2000 gals. per hour
Oiling Systems (any capacity, any machine)
Oil Filtering Systems (continuous)
Oil Tanks up to 5000 gals. capacity
Oil Pumps
Compression Pipe Fittings up to 1½ W. I. Pipe
Oiling Devices
Telescopic Oilers for C. H. Pins, Crank Pins and Eccentrics
Oil-from-the-floor-shaft Oiler
Sight Feed Valves (Removable Glass)
Flow Alarms and Indicators
Sight Flows

NUGENT TRADE MARK

Since 1897

WM. W. NUGENT & CO., INC.

411 N. Hermitage Ave., Chicago

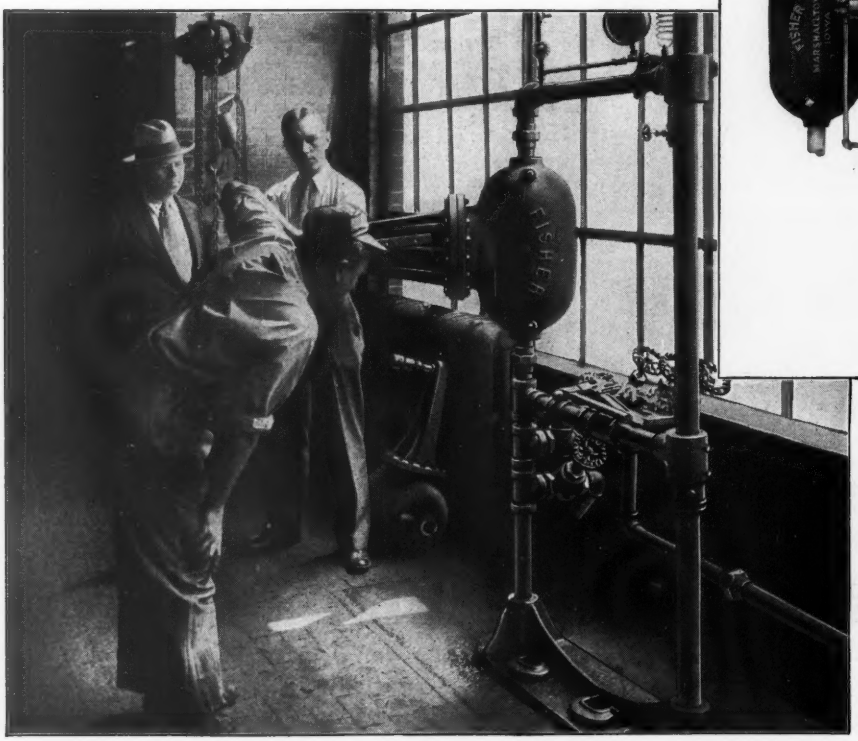
Tremendous Discharge at Highest Pressures

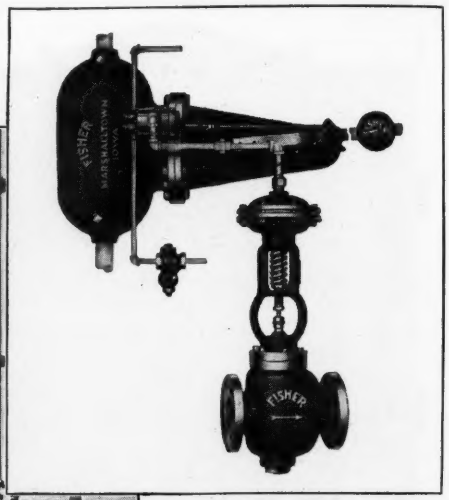
THE Cochrane Discharger is a pilot actuated trap with positively operated discharge valve of large area, for draining steam purifiers and other severe duty. Built for pressures of 1350 lb. per sq. in. and higher.

Ask for Bulletin H-685.

Cochrane Corporation
3144 North 17th Street
Philadelphia, Pa.

D 11-2





The Type 235 Fisher Liquid Level Controller assures extremely close and positive regulation of liquid levels in stills, towers, tanks, receivers, etc. when as much as 200' separates float cage and main valve. The pilot valve and operating fluid (air, gas, water or oil) translate the slightest float movement into a positive force that easily and instantly increases or decreases the flow through the main valve even when handling viscous fluids.

"You don't take *anything* for granted, do you?"

"THE operation you see here is interesting principally because it answers your question. Of course, it is to your advantage that we take nothing for granted, but at the same time we also have a selfish purpose. We simply cannot afford to jeopardize the reputation we have been building for 50 years by taking even the slightest chance.

"The float cage for every Fisher liquid level controller is tested for leakage with kerosene at a pressure equal to 150 per cent of the maximum working pressure of the controller. You know many of these controllers are used on oil at high temperatures where a leak would mean a flash and a fire.

"This operation is typical of the care taken in building all Fisher Specialties—one important reason why you have always been able to depend upon them."

FISHER
THE MARK
OF SCIENTIFIC
FLUID CONTROL

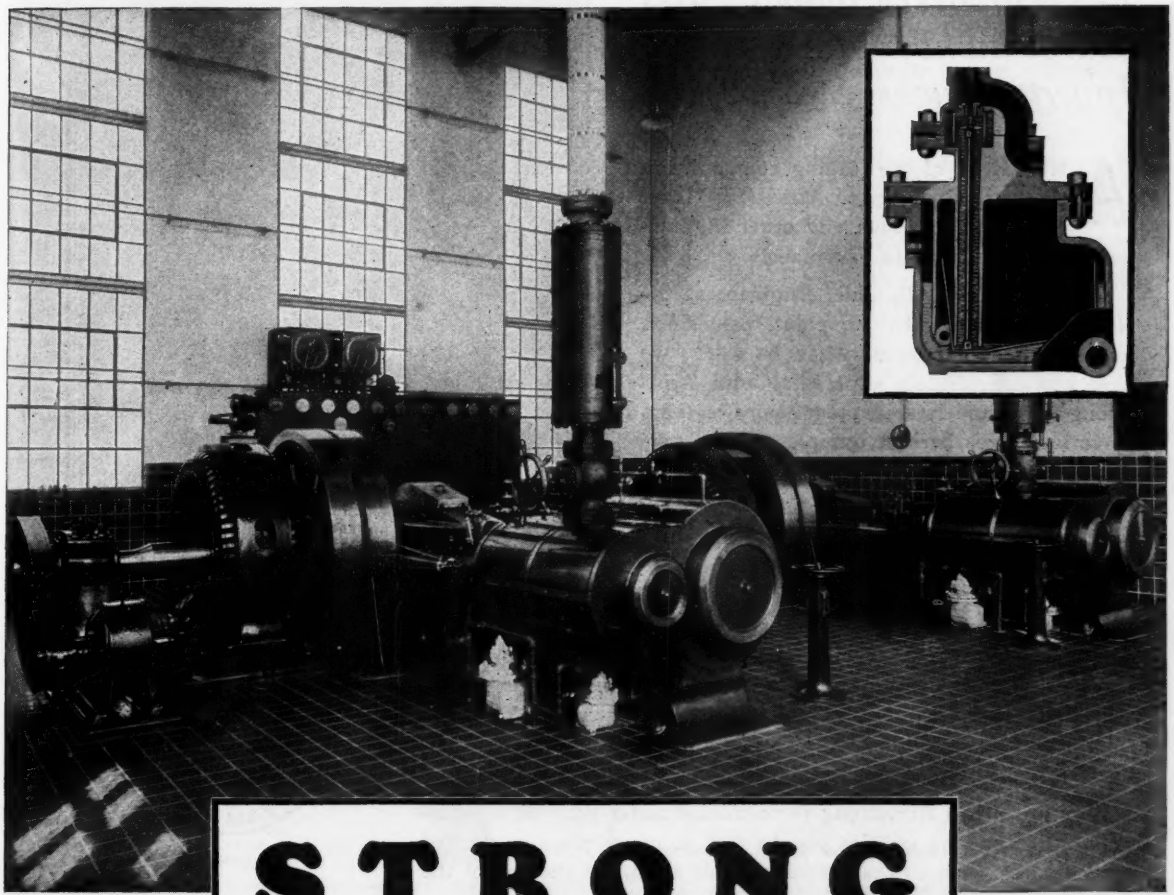
THE FISHER GOVERNOR COMPANY
1200 Fisher Building Marshalltown, Iowa

Traps on Harrisburg engines

IN this modern power plant of the North Carolina State Hospital at Morgantown, N. C., two 19 x 20 Harrisburg Dual Clearance Unaflow engines are direct connected to 190 K V A alternators,152 K W. Strong traps, draining the separators, insure dry steam at the throttles of both engines. Another trap is used on each engine for draining the steam jackets of the cylinders.

All four traps are operating with highest efficiency—an attribute of all Strong traps.

Builders of these well-known engines and hospital engineers interested each had a voice in selection of Strong traps for this important installation. And each one knew from long experience that Strong design and Strong construction was a positive and unfailing means of draining condensate with minimum cost for maintenance. Valve seats and discs of all Strong traps are made of *ANUM-METL*, an almost indestructible alloy. Every Strong trap is guaranteed tight for one year from installation.



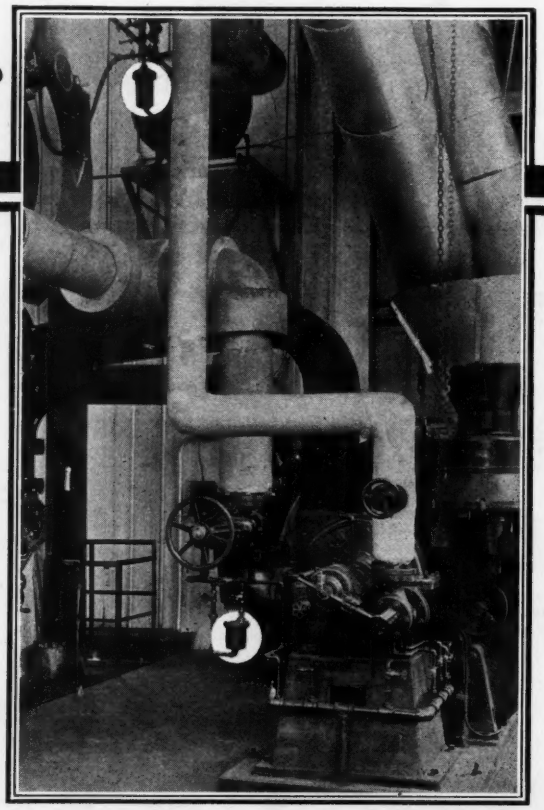
STRONG CARLISLE & HAMMOND

Among Strong steam specialties are Strong Steam Traps, Radiator Traps, Vacuum Traps, Pump Governors, Reducing Valves, Separators, Non-Return Valves.

3-Way Emergency Valves, Engine Stops, Instantaneous Closing Valves, Combined Throttle and Quick-Closing Valves, Balance Throttle, "EVR-TYTE" Globe Valves.

MANUFACTURERS OF STEAM SPECIALTIES · CLEVELAND, OHIO

Two leaders get together



The Wurlitzer Company uses a large number of Armstrong Inverted Bucket Steam Traps

ANOTHER of the leading companies in industry that rely on Armstrong Traps (more in use than any other mechanically operated trap) is Wurlitzer.

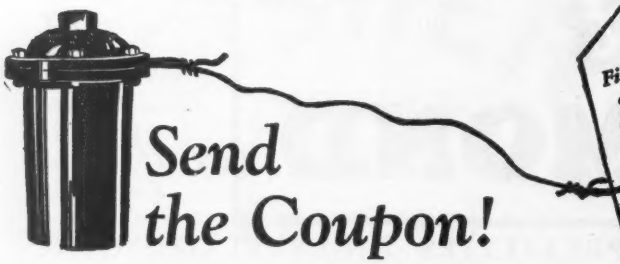
Mr. C. N. Deverall, Chief Engineer at the North Tonawanda, N. Y., plant, paid these traps a nice compliment when he said, "we have had considerable experience with Armstrong traps and have a great many of them of various sizes here in our plant . . . I personally have not given them attention . . . I have received no complaints in connection with them . . ."

It's characteristic of Armstrong Traps that you can install them and forget about them. It is not uncommon for Armstrongs to operate five years with no attention whatever. Their special design and construction eliminates air-binding; prevents clogging from scum and sediment; does away with wire-drawing with consequent valve scoring. They are small enough to be supported by connecting pipes, yet have capacities greater than most traps of much larger size.

Why not prove Armstrong performance under your own conditions? The coupon entitles you to test as many traps as desired for 3 months, without cost to you or obligation. At the end of the test, return the traps collect.

ARMSTRONG · INVERTED BUCKET · STEAM TRAP

Armstrong Machine Works
Three Rivers, Michigan

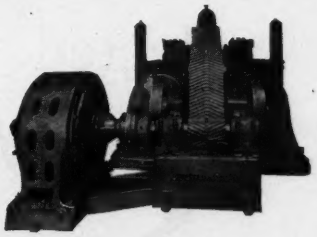


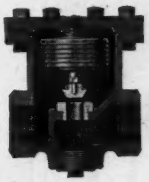
Send the Coupon!

To _____ (Name) _____ (Firm)
_____ (Position) _____ (City) _____ (State)
_____ (Street)
For _____ (Size and make of machine)
Size of Pipe _____ Steam Pressure (Max.) _____
☐ *Send Catalog* _____ *from*
ARMSTRONG MACHINE WORKS
THREE RIVERS, MICH.

Fill in and Mail For 90 Day Test

PPE 12-15 Gray

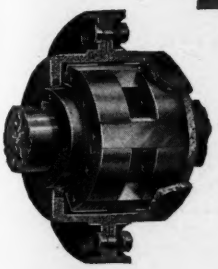




Nicholson New Industrial Steam Trap automatically insures ample drainage from 0 to 100 lbs.

Four-Way Valve operates easily and gives long wear

"hard service without a single failure"



No. 5 Nicholson Coupling connecting 100 H.P. Motor, 450 R.P.M., to Duplex Plunger Pump at Glen Alden Coal Co., Nottingham Mine, Plymouth, Pa. At left, sectional view of the coupling.

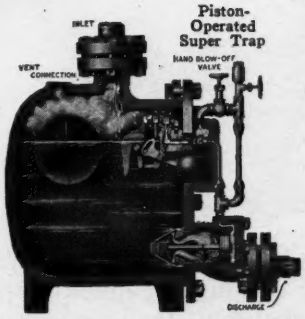
That's the record of the Nicholson Coupling in its large number of installations in industrial plants and central stations. And that record is upheld by the durable construction, simple principle and perfect operation of the coupling itself.

All-steel constructed, with no metal to metal contact, self-contained, dust-proof, the Nicholson Flexible Coupling is easily installed, and requires no attention other than occasional oiling. Our bulletin No. 329 describes this coupling fully. Write for it.

Nicholson Piston-Operated Super-Trap, in cast iron construction for pressures 2 to 200 lb., and in cast steel construction for pressures 2 to 600 lb., is especially adapted for draining steam purifiers and places where a large-capacity trap is required. Its discharge valve, of the non-wire drawing type, is entirely open or closed at all times.

The float, used in this trap, is our own patented design and construction. It is made in halves, of chrome-nickel steel welded together, heat treated and nickel-plated to prevent corrosion and is guaranteed to be absolutely non-collapsible for any steam working pressure up to 1350 lb. Write for full details about the Nicholson Line.

Piston-Operated Super Trap



W. H. NICHOLSON & COMPANY

120 Oregon Street, Wilkes-Barre, Penna.

SARCO Self-Adjusting STEAM TRAP

Simply screw the Sarco Steam Trap No. 9 into your pipe-line and it is ready for business at pressures from 0 to 100 lbs. It is self-adjusting—nothing to adjust.

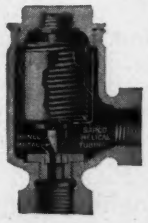
That saves time. Saves work. Eliminates possibility of wrong adjustment by inexperienced help.

It drains all condensation as soon as formed. Doesn't leak—doesn't waste steam. There is no steam hammer. Cannot air bind.

Is simple in operation. Has only one moving part—nothing to get out of order.

Needs no floor space or building up, and can be placed anywhere on the line.

It costs about one-third the price of bucket or float traps. Sold on 30 days' free trial. Booklet B-95 on request.



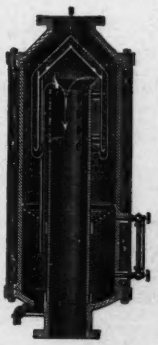
SARCO CO., Inc.
183 Madison Avenue, New York City
Branches in Principal Cities

Thorough and Dependable

Sweet's Steam Separator

delivers steam 99.8% dry. No complicated parts to become deranged. Built of the best materials and made to give years of faithful service.

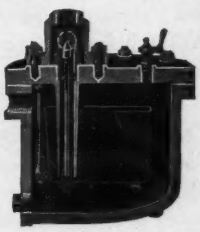
Try one for 60 days. Full information upon request.



The Direct Separator Co., Inc.,
218 So. Geddes St. Syracuse, N. Y.

15,000 in service

McDaniel Intermittent Steam Trap *Saves Steam*



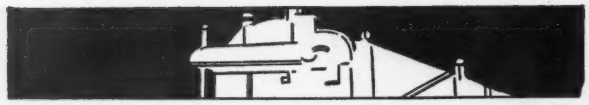
Features include baffling of the outlet tube to prevent swirls of condensation, restricting passages to cut down the velocity of the discharge and heavy flanges to prevent the gasket from blowing out. The McDaniel Intermittent Steam Trap has been designed with all the experience of fifty years of trap manufacturing.

The Intermittent Trap will discharge only when the open float is filled with condensation. After condensation is discharged to a predetermined level, maintaining a water seal over the discharge tube, the trap closes the discharge valve until the float is filled again.

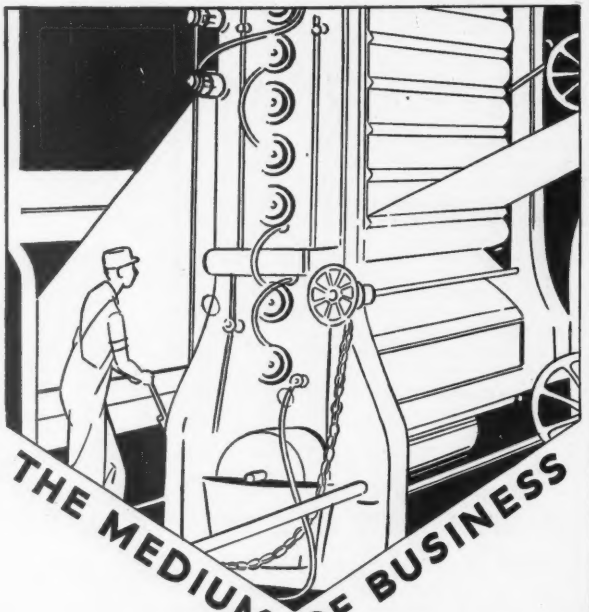
Investigate all the details of this trap. For use wherever condensation collects and is to be discharged without loss of steam.

Send for Complete Catalog.

WATSON & McDANIEL CO.
Manufacturers of Steam Saving Devices
448 N. Marshall St., PHILADELPHIA, PA.



PAPER IS INDISPENSIBLE

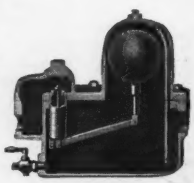


The world could not do without paper—no more than the paper mill can do without steam traps. For draining driers, for use on drips and separators and wherever else traps are needed the Wright-Austin "Emergency" Trap for high pressures and the Wright-Austin "Victor" Trap for low pressures have been giving ideal service for 25 years.

Each is unique in its own particular field. The "Emergency" Trap will handle all pressures from 0 to 200 lbs. without change of valves or adjustments and all loads without wire drawing. The "Victor" Trap for pressures up to 20 lbs. will operate satisfactorily on a cold heating system, and will successfully discharge oil and grease from oil separators without choking. It has a very high capacity at low pressures.

"Emergency" Trap

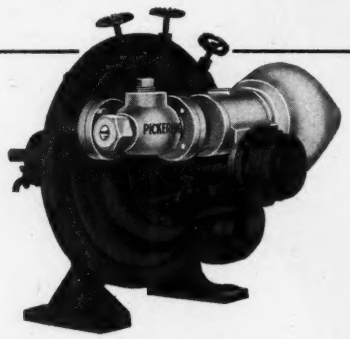
Send for Bulletin Number 201



"Victor" Trap

WRIGHT AUSTIN CO
DETROIT
2231 PARK AVE.

Selected for *Quick* responsiveness on Coppus Turbines



ON STEAM turbines, as on other types of power equipment, quick responsiveness to changing loads is essential to satisfactory performance.

On Coppus Turbines accurate speed control is assured by the use of Pickering Governors. Exhaustive tests conducted by the Coppus Engineering Corporation demonstrated the high efficiency and dependability of the Pickering in providing close regulation under all conditions.

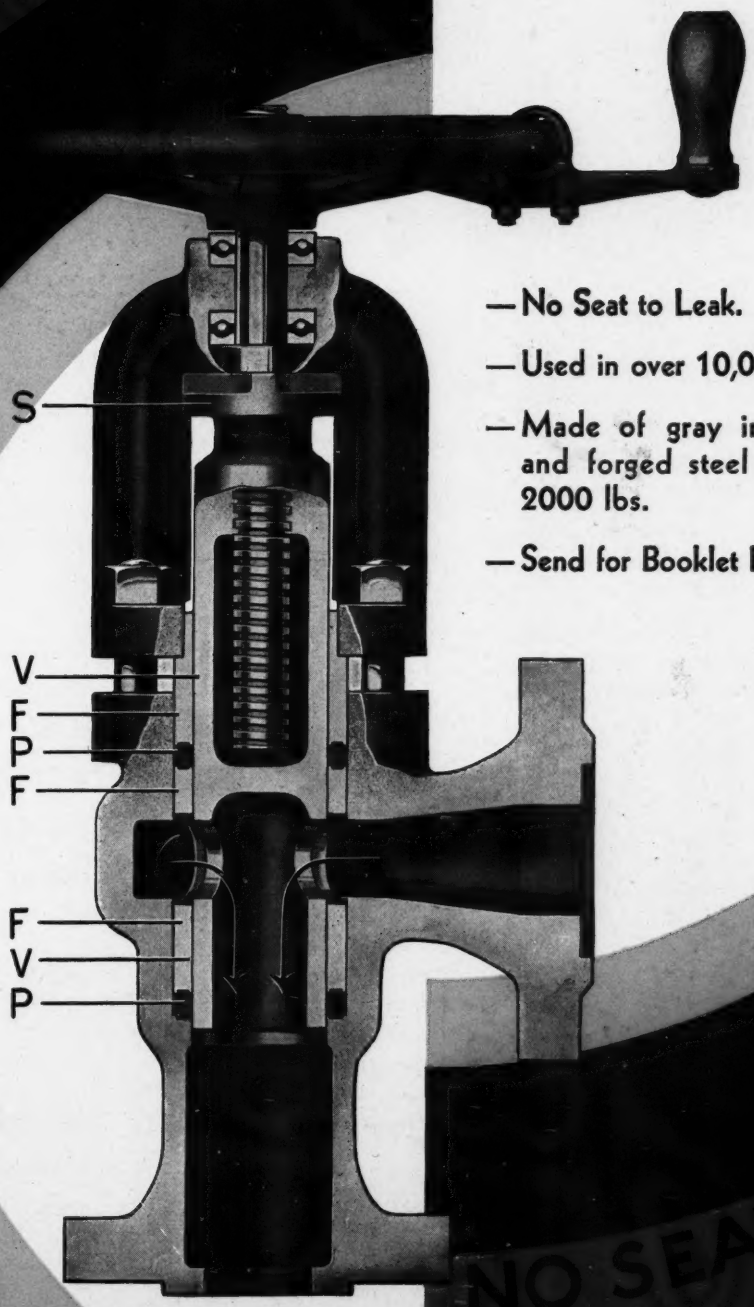
For 68 years Pickering Governors have been used by leading engine and power equipment builders.

Pickering Governors are made for steam engines, paper machine drives, unloaders and other power equipment. Special models with extra heavy valve chambers and valve and seat of "Monel" metal are available for use with high pressure steam. Consult our engineers about your governor requirements. Address Engineering Department, The Pickering Governor Co., Portland, Conn. Governor builders since 1862.

PICKERING GOVERNORS
—— SPLIT-SECOND CONTROL

YARWAY

BLOW-OFF VALVES



— No Seat to Leak.

— Used in over 10,000 plants.

— Made of gray iron, electric furnace and forged steel for all pressures to 2000 lbs.

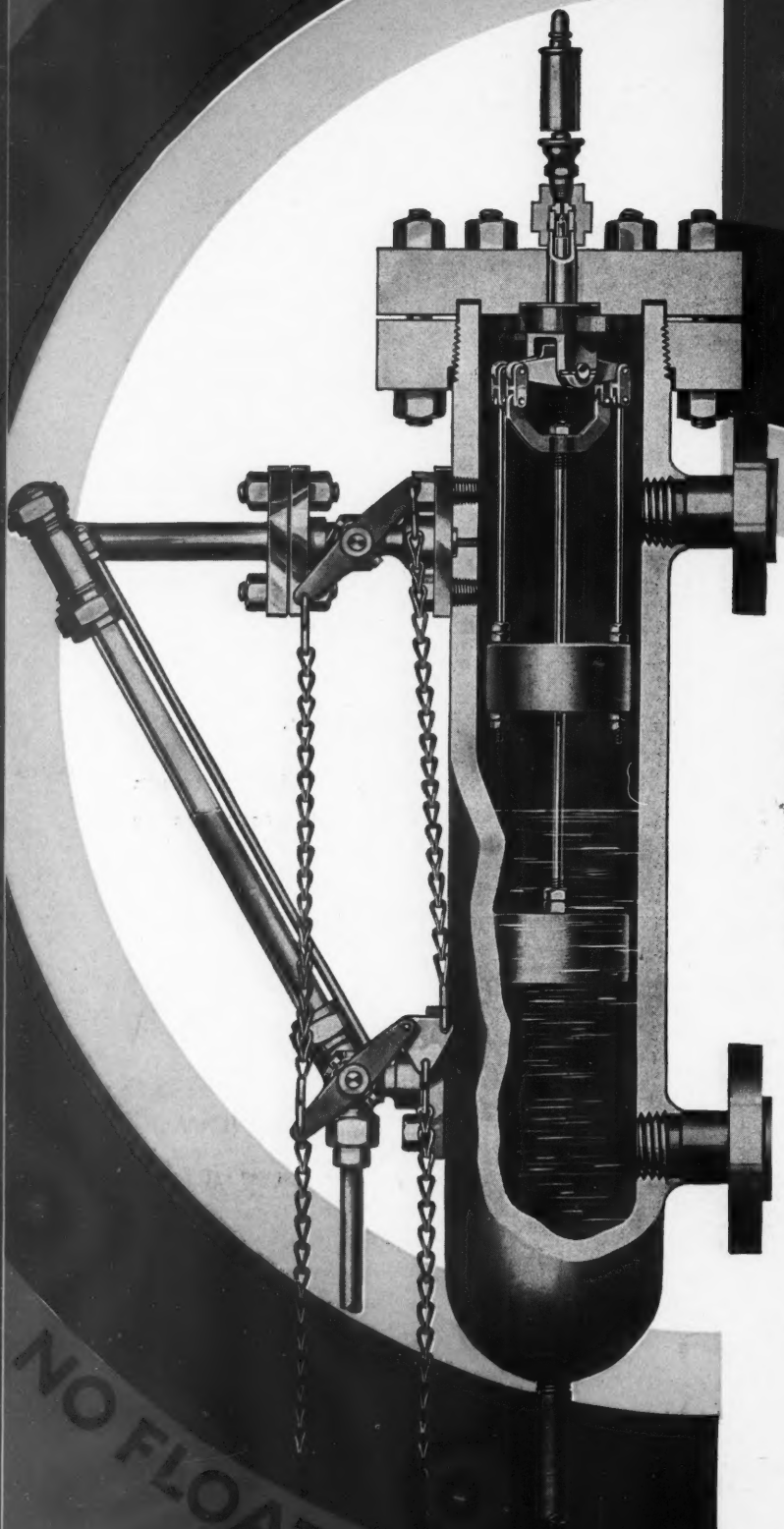
— Send for Booklet B-417

YARWAY SEATLESS VALVE Operation: After valve is closed, shoulder S on plunge contacts with upper follower gland F, forc it down into body and compressing pack P above and below port.

NO SEAT TO LEAK

YARNALL-WARING COMPANY

YARWAY



FLOATLESS HI-LO ALARM WATER COLUMN

and

SE-SURE INCLINED WATER GAGE

— Operates on the displacement principle with Solid Weights—has no floats.

— Inclined Gage Glass for easy reading of high boiler water levels.

— Used in leading plants from coast to coast; from Canada to the Gulf.

— Made of gray iron and forged steel in types for low and high pressures.

— Send for Booklet WG-1802.

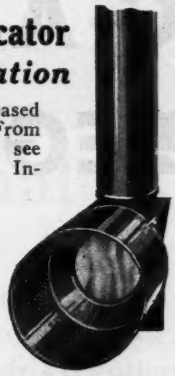
NO FLOATS TO SINK

YARNALL-WARING COMPANY
Mermaid Street Philadelphia

ECLIPSE Smoke Indicator
Simplifies Fire Regulation

Combustion efficiency is easily increased with the Eclipse Smoke Indicator. From the boiler room floor, operators can see the flue gases instantly and constantly. Inexpensive and no upkeep costs.

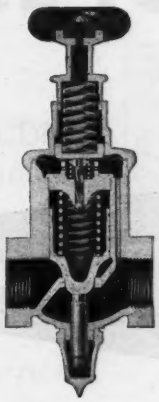
Write for information



Boiler Room Improvement Company

Chicago Office and Factory
4057 W. Van Buren St.
New York Branch, 39 Cortlandt St.

CURTIS
ENGINEERING SPECIALTIES



Type D

Our experience and records, the accumulation of over 61 years, are available in advising you on your pressure regulating, temperature control and steam drainage problems.

Built for service — not to meet a price.

See Our Exhibit
Chicago Power Show
Booth No. 21

JULIAN D'ESTE COMPANY
6 Spice St. (Charlestown Dist.)
BOSTON, MASS.
Established 1870

Trade Mark

R-K TRADE MARK REG. U.S. PAT. OFFICE

Solenoid Operated Valves arranged for D.C. and A.C.
Servo Motors Operated by Double Solenoids
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Regulating Equipment includes a wide range of devices that meet the demand for *accuracy and dependability*

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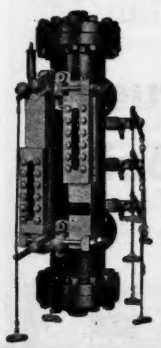
"Reliance" Has Meant Boiler Safety Since 1884



RELIANCE Safety Water Columns in standard and special types up to 1800 lbs. pressure. Forged steel columns specially designed for 250 lbs. up. Standard and special floats of nickel, copper, and fused Monel for pressures up to 1200 lbs. Water gauges and gauge cocks for pressures up to 1500 lbs.

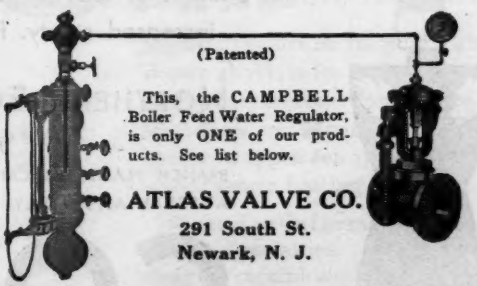
The Reliance Gauge Column Company, 5932 Carnegie Ave., Cleveland, Ohio.

Reliance
SAFETY WATER COLUMNS

When you deal with the

ATLAS VALVE COMPANY
REGULATING VALVES FOR EVERY SERVICE

you deal with a concern that has had experience with *all kinds of regulation problems*



(Patented)

This, the CAMPBELL Boiler Feed Water Regulator, is only ONE of our products. See list below.

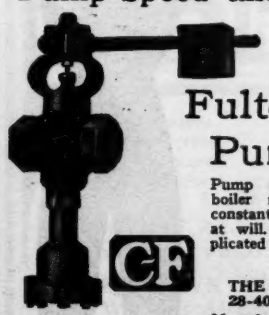
ATLAS VALVE CO.
291 South St.
Newark, N. J.

Manufacturers of Regulating Valves for Every Service

On which do you want information?

- ☐ Campbell Boiler Feed Water Regulators
- ☐ Reducing Valves
- ☐ Damper Regulators
- ☐ Temperature Regulators
- ☐ Pump Governors
- ☐ Float Valves
- ☐ Swing Joint Fittings
- ☐ Bronze Unions
- ☐ Thermostats
- ☐ Balanced Valves
- ☐ Control Valves

Pump Speed and Excess Pressure



are both under absolute control when feed water to the boilers is regulated by the

Fulton Boiler Feed Pump Governor

Pump speed is always in accord with boiler requirements. Excess pressure is constant, as predetermined, and changed at will. Automatic operation. No complicated parts. Removable valve seats.

Write for circular.

THE CHAPLIN-FULTON MFG. CO.
28-40 Penn. Ave. Pittsburgh, Pa.

Manufacturers of the Vigilant Feed Water Regulator and Other Steam Specialties

ANNOUNCING A NEW COPES REGULATOR

The COPES Type OT

This new COPES Regulator is rugged, compact, dependable. Easily installed and self-supporting. Simple, permanent adjustment. In every way worthy of the name COPES—the world-wide standard of long life and superior performance.

A NEW Thermostat

A tension type thermostat with two short tubes connected at an angle to give the effect of a single expansion tube. Less than 37 inches long. Less than 17 inches high. Cased in malleable iron to withstand shocks and strains in service. It clamps to a vertical feed line, with no other support needed. Quick acting.

A Time-Tested Valve

The new COPES Type OT Regulator uses the almost-frictionless, fully-balanced Type BI Valve . . . world-famed for its splendid performance in thousands of installations . . . in sizes up to 2-inch. Accurate.

A new special design for Horizontal Return Tubular, Oil Field and Scotch Marine Boilers

Now . . . for the first time . . . COPES offers a special design of regulator for these small boilers . . . bringing to their users the benefits of COPES Regulation . . . fuel and labor saving, increased safety. For facts, ask for Folder OT.

NORTHERN EQUIPMENT COMPANY

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BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY, AUSTRIA AND ITALY. REPRESENTATIVES EVERYWHERE.

COPES

SYSTEM OF BOILER FEED CONTROL

Exceptional . . .

. . and so with **MERCON** The inherent simplicity, ruggedness and accuracy of the MERCON prove it **exceptional.**

. . **Exceptional** thru its complete elimination of weights, spring and packing.

. . **Exceptional** as it carries a guarantee to solve your problems in pressure and flow regulation.

MERCON REGULATOR COMPANY
ONE LA SALLE STREET
CHICAGO

Manufacturers of Industrial Instruments

CO_2 Recorders
Draft Instruments
Thermometers
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Boiler Meters
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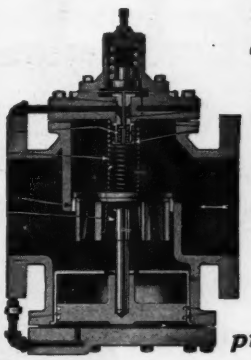


KIELEY
REGISTERED TRADE MARK

Steam, Water Air, Gas Specialties

for dependable pressure regulation

The Line that is noted for Quality and Simplicity

Kieley Pressure Regulating Valve, shown above, is for high pressures and temperatures. Constructed of Cast Steel and Monel Metal. Also comes in types for application on low-pressure heating systems.

Write for information about Kieley Specialties. Their simple designs, careful workmanship and high-grade materials are the factors that enable them to give unexcelled service.

KIELEY & MUELLER, Inc.
36 West 13th St., New York City

Coal the biggest single item in your power cost—

should be accurately checked for each boiler

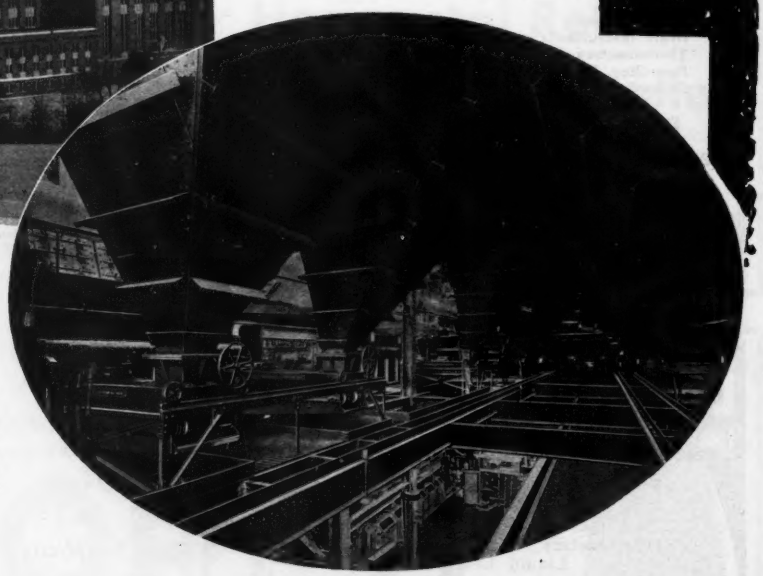
DO YOU FORGET the most important item in producing power?

You meter your steam, boiler feed water, temperatures, flue gases—but what about your coal? Do you estimate the amount—or base your fuel consumption on carload weights? What about the efficiency of EACH boiler?

Today, in the face of keen competition, it is no longer possible to "get by" with antiquated methods. Exact records are kept of production, labor costs, *and* steam costs.

Therefore, it is important to WEIGH YOUR COAL *to each boiler* so that you will know at all times whether each boiler is performing economically. Richardson Automatic Scales give accurate and complete records of coal consumed. The accuracy is guaranteed to be within ½ of 1%. They are entirely automatic in operation.

A copy of our Bulletin 2129-PP, "What Price Power," can be obtained from any of our offices. It is worth reading.



Philo, Ohio, Station of The Ohio Power Company, where twelve (12) SPECIAL ELONGATED Richardson Apron Feed Automatic Crushed Coal Scales are installed to accurately check coal consumption of boilers.

Richardson Scale Company

Clifton, New Jersey

Chicago New York Minneapolis Los Angeles Boston Wichita Omaha Philadelphia Atlanta
Agents for Eastern Canada, Messrs. Peacock Brothers Limited, Montreal

NEKOOSA-EDWARDS PAPER COMPANY
PORT EDWARDS, WISCONSIN

WIDENING THE MARGIN OF PROFIT

In the race of competition power must be generated with economy and used without waste. It is costly procedure for operators to grope in the dark—blindly guessing when to change fuel feeds or air supply, blow tubes, repair baffles and other operations.

Minimum power costs are obtained at Nekoosa-Edwards Paper Company, Port Edwards, Wisconsin, by use of Bailey Meters. In the boiler room Bailey Boiler Meters, Multi-Pointer Gages, Pressure Recorders and Temperature Recorders inform the operators of changing conditions. They tell when to make the readjustments necessary with fluctuations of load. Most important, however, they enable the operators to constantly maintain maximum combustion efficiency consistent with economical operation.

In the turbine room too Bailey Fluid Meters and Recorders act as guides to satisfactory turbine performance.

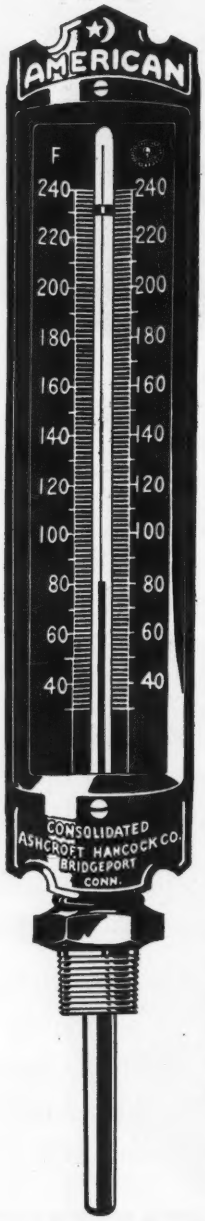
Modern industrial plants everywhere are widening the margin of profit by installing Bailey Meter Equipment. For further details write for bulletins Nos. 43 and 162.

BAILEY METER CO.

1040 IVANHOE ROAD CLEVELAND, OHIO.

Bailey Meter Company Limited, Montreal, Quebec

American INSTRUMENTS



AMERICAN Indicating Thermometers have won high regard in every industry in which the accurate measurement of temperatures is important. Their slightly higher cost is more than justified when it is realized that one spoiled batch of product is worth the price of a dozen of the best thermometers made.

American Indicating Thermometers are accurate and dependable. Monel metal bulb chambers are used for maximum strength and for utmost protection against corrosion. Careful annealing of the glass tubes insures sustained accuracy at high temperatures.

CONSOLIDATED
ASHCROFT
HANCOCK

Consolidated Ashcroft Hancock Co., Inc.
Bridgeport, Conn.
Subsidiary of Manning, Maxwell & Moore, Inc.

Specify Catalogs Desired:

American Dial Thermometers	G-34	American Recording Gauges	E-34	Consolidated American Safety and Relief Valves	Z-34
American Glass Thermometers	F-34	American Draft Gauges	B-34	Hancock Bronze Valves	WB-34
American Recording Thermometers	H-34	American Gauge Testers	D-34	Hancock Cast Steel Valves	WA-34
Ashcroft American Gauges	A-34	American Tachometers	J-34	Hancock Forged Steel Valves	W-34
American Temperature Controllers	R-34	Ashcroft Power Control Valves	M-34		

BRISTOL'S

RECORDING GAUGES

Guide in Maintaining Uniform Pressure and Vacuum.

INSTALLED to record steam boiler pressure, superheated steam pressure, main line pressure, boiler draft, condenser operation, etc., these instruments enable operatives to determine at a glance, not only what the vacuum or pressure is at the instant of reading, but what it has been during hours past, and the future trend. Also as each chart is marked off in time arcs, the exact time and extent of changes are clearly defined. Thus inefficiencies can be noted almost as soon as they occur, and correction made before serious loss or trouble develops.

The two models of Bristol's Gauges illustrated are well suited to Power Plant work. Case construction is dust-, fume- and moisture-proof. The inverted pen-arm arrangement is standard, assuring a clear, clean-cut record. Can be furnished for either wall or switchboard mounting or for portable use—

But get complete details—new Gauge Catalog No. 1009 will be sent immediately to any interested person in your plant. Write—

THE BRISTOL COMPANY

Waterbury, Connecticut

BRANCH OFFICES:

Boston	Philadelphia	Detroit	St. Louis
New York	Akron	Denver	San Francisco
Pittsburgh	Birmingham	Chicago	Los Angeles

Encased against moisture and dust, this Tycos Pyrometer charts the temperature of flue gases at any point desired in Furnaces, Superheaters, Stacks, etc. Second-by-second for 50-days without changing the chart, the temperature line is drawn for all to see

In Combustion — the first process of power generation

Tycos TEMPERATURE INSTRUMENTS
Indicating Recording Controlling

keep constant watch over every variation

Whether the fuel that goes into the furnace comes out as useful heat or as waste carbon in the ash pit or up the chimney, is the problem of the boiler room force and the anxiety of the management.

Tycos' instantaneous indications and unquestioned records are accepted by firemen, chief, owners, fuel supply men, and equipment makers for every question as to conditions inside the furnace.

They tell what to do and when to do it. They place the blame and show the measure of success.

64-page catalogue sent on request

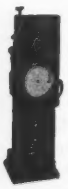
CANADIAN PLANT TYCOS BUILDING TORONTO

Taylor Instrument Companies
ROCHESTER, N.Y.U.S.A.
There's a *Tycos* or *Taylor* Instrument for Every Purpose

MANUFACTURING DISTRIBUTORS IN GREAT BRITAIN SHORT & MASON, LTD., LONDON

Tycos "The Sixth Sense of Industry" Tells the Inside Facts

TYPE M VENTURI METER BULLETIN 190



TYPE Y VENTURI METER BULLETIN 233

BUILDERS IRON FOUNDRY
"Builders of the Venturi Since 1891"
15 CODDING ST. PROVIDENCE, R.I.
VENTURI
"VENTURI" Registered

TYPE GK DIAPHRAGM METER BULLETIN 236

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WATER *Softening*
Boiler Concentration Control
Water Conditioning, Purifying,
Heat Exchangers—Feed Water Filters
Elgin Softener Corporation
MANUFACTURERS WATER CONDITIONING EQUIPMENT
EST 1909
ELGIN, ILLINOIS
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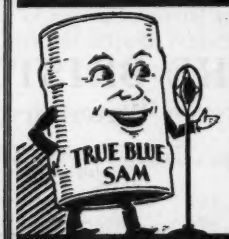
TRUE BLUE
A Successful, Guaranteed Boiler Treatment



Protect your boilers with **TRUE BLUE.** *Tried and proven against scale, oil, pitting, rust and corrosion*

ECONOMY LUBRICATING CO.
Established 1909
Charlestown, 29, Massachusetts.

Also Makers of **ECONOMY GREASE**

There's a four-fold economy in using

FILTRATORS

Send in the coupon and get all the facts, in detail.

FIRST:—Old scale is broken up so as to be easily removed—formation of new scale is prevented—saving fuel and upkeep.

SECOND:—Pitting, grooving and corrosion are done away with—another saving in upkeep.

THIRD:—There's no foaming, no priming, no wet steam—another economy factor.

FOURTH:—The troubles caused by oil getting into the boiler, are eliminated.

AND—the cost of doing all this with the "Filtrator" is usually much less than that shown by any other method of feedwater treatment.

Filtrators Co., Inc.,
96 Liberty St., New York.

Send your book "Reducing the Cost of Boiler Operation," to:

Name .....

Company .....

Address .....

P.P.E.-12-15

FILTRATORS COMPANY, INC.

96 Liberty Street New York City

"Inspector reported them in A-1 condition, perfectly free from scale"

HAWK-EYE

Thus reported a Chief Engineer who had used Hawk-Eye Compounds for twenty years in his boilers. Give your boilers a chance to make good for you.

How about your boilers?

Hawk-Eye Compound Co.
(Not Inc.)
Blue Island, Illinois

HAWK-EYE COMPOUNDS

WHY do MOHAWK users STAY SOLD?

BECAUSE -

It is economical
It is efficient
It is always uniform
It gives satisfaction

A TRIAL WILL CONVINCE YOU

The MOHAWK Water Treatment Co.
10116 Detroit Ave., Cleveland, Ohio

Get this

new booklet on how to prevent boiler troubles!

THIS attractive booklet explains "Magic" and how for ***Twenty-Five Years*** it has prevented scale, corrosion and pitting in boilers.

MAGIC

Mailed on request

GARRATT-CALLAHAN CO.
San Francisco — Chicago — New York

MAGIC BOILER
"The FILM of PROTECTION for BOILERS"
PRESERVATIVE

This huge soap company has used K.W.S. for five years

EXAMPLE No. 8, of K.W.S. users is one of the largest producers of soap in the world. Its products are as familiar to most of us as our own names. It uses K.W.S. in three plants located in three different states.

K.W.S. SODIUM ALUMINATE

No. 8 of a series describing customers who use K. W. S. Treatment.

This manufacturer discovered five years ago that K.W.S. Sodium Aluminate greatly improved the water at one plant where, for a variety of reasons, the water was extremely difficult to handle. The other two plants were put on K.W.S. treatment in due course.

We have now described eight large manufacturers using K.W.S. in 101 plants, an average of 12⅝ plants each and spread over an average of six states each. Among these eight customers alone K.W.S. has satisfactorily proved its value under *101 different operating conditions.*

These companies keep a careful watch of steam production and its cost. They do not guess—they know. They use K.W.S. because it pays them to do so but if anything better or cheaper could be found they would use it. There are thousands of smaller users, equally satisfied.

What It Will Do

K.W.S. Sodium Aluminate is not a cure-all and in most cases is only a part of the treatment. The complete treatment will include other low priced, standard chemicals selected for their particular action. This gives a flexible and simple but positive treatment determined by the requirements of each plant. The easy and simple tests, which are quickly learned, enable you to keep a constant check on the raw and treated water and also to control your blow-down scientifically instead of guessing at it.

Thousands of engineers have, by adopting the K.W.S. system, learned how to treat water intelligently and in so doing have eliminated scale, corrosion and carry-over. This, of course, means more efficient operation due to constantly clean boilers, fuel, oil and labor saving, steady steam production, etc.

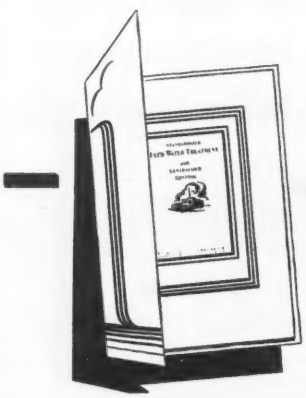
What these men are doing you can do. The first step is to fill out and mail the coupon below.

NATIONAL ALUMINATE CORPORATION

6224 West 66th Place, Chicago, Illinois

Specialists in water softening, filtration, process work, waste water disposal, and all problems involving water supply and treatment.

The National Continuous Blow-Down and Heat Reclaimer is paying big dividends wherever installed. Wouldn't you like to investigate the savings possible through the installation of this equipment in your plant? Use the coupon.



THIS BOOK FREE!

NATIONAL ALUMINATE CORPORATION,
6224 W. 66th Place, Clearing Sta., Chicago, Illinois.

If it pays others to use K.W.S. perhaps it will pay me also.

☐ Please send me your booklet—"Standardized Feedwater Treatment," free of charge.

☐ I am interested in National Continuous Blowdown and Heat Reclaimer. Please send more information.

Name .....

Company .....

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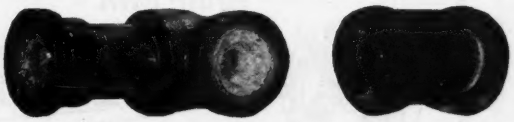
P.P.E. 12-15-Gray

Cleaning Out Scaled Equipment *Simplified*

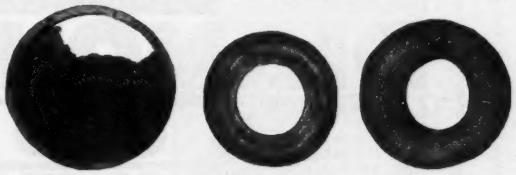
When scale has been allowed to collect on evaporating surfaces, the treatment used for its removal depends upon the composition. Where silicates or calcium sulphate are the principal components, treatment for boiling out is specified. If the scale is of such a nature as to make this procedure impractical, regular feed water treatment may be prepared to be used in comparatively large dosages and in this way a gradual disintegration and solution is effected.



In deposits made up principally of carbonates, rapid cleaning methods are available. Dearborn Special Formula No. 134 has been standardized for this purpose.

By circulating a mixture of this treatment and water, feed lines, heaters, cooling coils, Diesel engine heads and jackets, condensers, pumps, evaporators, water meters, pasteurizers and boilers may be freed from scale in very short periods of time. An average thickness of scale is cleaned off completely in one to three hours.

Extra heavy deposits require a longer time proportionately, but no deposit can be too heavy for complete removal as long as the treatment mixed with water can be forced into contact with the surface of the scale. The



dissolved and disintegrated scale is drained off and the equipment thoroughly washed. Dearborn Special Formula No. 134 is reliable and completely effective, eliminating danger of acid or the laborious and expensive use of hand tools. By this means the equipment may be returned to service at its original efficiency within a few hours.

Here as elsewhere the service of the Dearborn Chemical Company follows the product to the satisfactory accomplishment of the purpose for which it is sold. Where practicable, a representative of the company will be present to assist in your first use of Dearborn Special Formula No. 134. In any event detailed instructions will be supplied.

A well known manufacturer of Diesel engines recently sent out a circular letter advising their customers that if they are having scale in their water jackets, the best treatment for this trouble is Dearborn Special Formula No. 134. A meter manufacturer with seventy-five salesmen instructed them to specify Dearborn Special Formula No. 134 for cleaning meters all over the United States.

If you have any scaled equipment, discuss best methods of cleaning with the Dearborn representative who calls on you or write us for recommendations, sending a sample of the scale or the scale-forming water.

DEARBORN CHEMICAL COMPANY

310 So. Michigan Ave., Chicago
205 E. 42nd St., New York

Canadian Factory and Offices:
2454-64 Dundas Street, West
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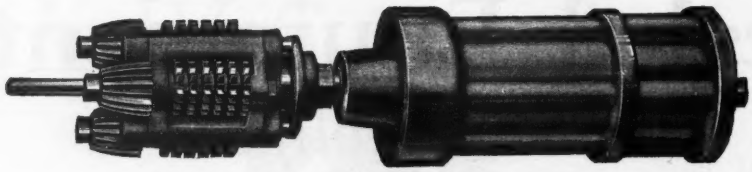
Dearborn
TRADE MARK REGISTERED

Special Formula No. 134

On an EIGHT-BOILER BATTERY by cleaning FOUR TIMES A YEAR, the ANNUAL CLEANING TIME was REDUCED from 28 to 18 DAYS. This enabled the plant to CARRY ITS LOAD WITH SEVEN CLEAN BOILERS, leaving the EIGHTH AS A SPARE!



Roto 4-in. Heavy Duty Air-Driven Tube Cleaner

ROTO CLEANERS CAN BE FURNISHED FOR EVERY SIZE AND TYPE OF TUBES

THE ROTO COMPANY, Sussex Avenue and Newark Street, NEWARK, N. J.

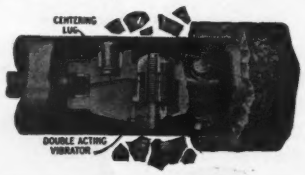
With a Torpedo L. L. Ralston, chief engineer, St. Lukes Hospital, Cedar Rapids, Ia., got 325 lbs. of scale from a boiler he thought was clean.

You can try it out on one boiler and if you don't like it return it. Send for it today.

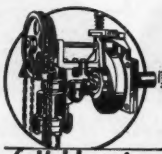
The General Specialty Co., Inc.
70 Carroll St.,
Buffalo, N. Y.

The TORPEDO TUBE CLEANER for fire tube boilers

Here's a safe cleaner that gets off all the scale. It has a short, quick stroke that is perfectly balanced and never severe. It's a treat to see it work. Get nothing but a Torpedo for fire tube boilers.

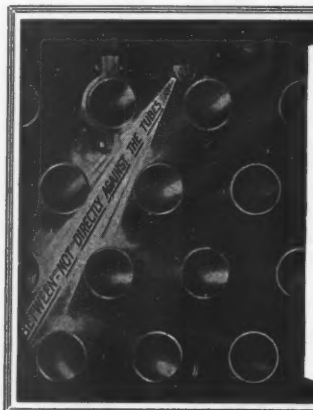


To Reduce Fuel Bills
equip with



BAYER SOOT BLOWERS
full blowing force properly directed

THE BAYER COMPANY
1506 South Grand Blvd.
St. Louis, Mo., U. S. A.



VULCAN Diagonal Method of Blowing

takes advantage of the diagonals formed by the tubes, in the staggered tube type of boilers, through which cleaning jets of steam can pass, scrubbing along the tubes clear to the bottom row, but never directly against them.

Special bulletins describing Vulcans for various types of boilers will be gladly sent upon request.

VULCAN Soot Cleaner Co.
Du Bois, Pa.

DIAMOND SOOT BLOWERS

Please write for bulletin on boiler cleaning by modern methods.

DIAMOND POWER SPECIALTY CORPORATION-DETROIT

120 HENSZEY De-Concentrators
for Automatic Continuous Blow-Down
are now installed in
107 PLANTS
totalling
367,732 Boiler Horse Power

HENSZEY DE-CONCENTRATOR CO.
Watertown, Wisconsin

WATER PURIFIED
for every industrial and domestic use

Water Softening Apparatus of every variety
Filters—pressure and gravity
Steel Tanks for air, gas and liquids

128 years old, founded 1802

Wm. B. Scaife & Sons Co. Main Office OAKMONT, PA.
Pittsburgh New York Chicago

FACTS

WHEN you are seeking the solution of your boiler scale problem or are in need of a cleaner for tubes of any description, consider these FACTS.

THE Dean Cleaner is designed for operation in both return tubular and water tube boilers and thoroughly removes all scale and hard soot from the tubes of both.

THE Dean is also used with equal success in the tubes of condensers, economizers, etc.

THE Dean is the pioneer vibratory cleaner and is now in its 33rd year. In these many years the Dean has been successfully used under every possible condition.

THE Dean is used in every state in the Union and in 52 foreign countries.

THE Dean is used by every line of industry. For example, over 150 U. S. Railroad systems have purchased Deans for locomotive and shop work. One large Oil group has purchased over 500 Deans. This is but typical of other industries.

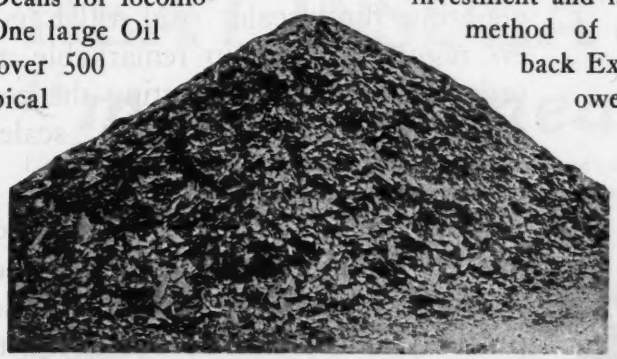
THE Dean never leaves a hard next-to-the-tube layer of scale for it is this layer that the Dean removes *first.*

THE Dean removes scale in slabs the *full* thickness of the deposit and from 3″ to 15″ in length, and thus produces not only a more thorough, but also a more rapid job than other methods.

AND MOST IMPORTANT

You may test a Dean in your plant without cost and without obligation to purchase. Simply tell us the style of boiler and size of tubes in which you want to try a cleaner.

A Dean will be shipped you for trial. Unless it conclusively proves to you that it is a real investment and is superior to any other method of scale removal, send it back Express Collect and you'll owe us nothing.

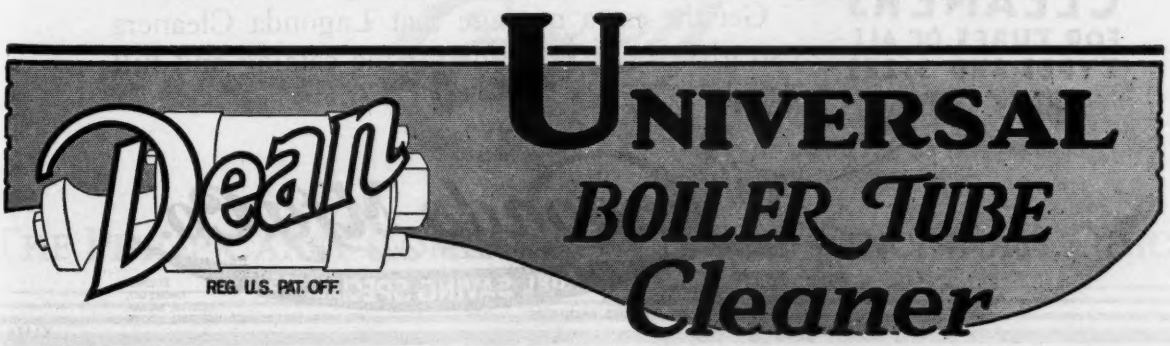


VISIBLE PROOF OF SUPERIORITY

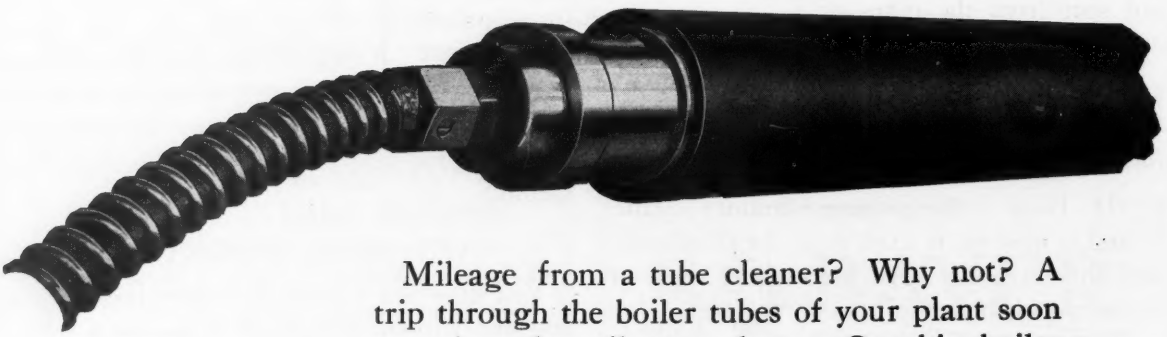
Six thousand pounds of profit-eating scale taken from the tubes of seven HRT boilers in a Chicago plant, by a DEAN after other cleaning methods had been used without success.

What would such a cleaning mean to you?

THE WM. B. PIERCE CO., 149 Ellicott St., Buffalo, N. Y.



More mileage *from* LAGONDA TUBE CLEANERS



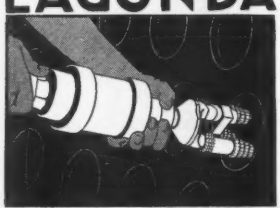
Mileage from a tube cleaner? Why not? A trip through the boiler tubes of your plant soon runs into the mileage column. One big boiler contains in itself six miles of tubes.

Remember, it is a tough trip for the tube cleaner. Every mile of progress is a battle against clogging, flinty scale. And still Lagonda Cleaners regularly hang up remarkable mileage records, dislodging and ejecting the costly deposit and leaving miles of clean, scale-free tubes behind.

Extra mileage is built into Lagonda Cleaners in every detail of construction. In the motor, for instance, all parts are made to close accuracy, precisely fitted, and hardened for the difficult service anticipated. Cutters and cutter-heads are hardened and heat-treated for maximum life. Years of experience have shown us how to build service into these scale-destroyers.

Get the extra mileage that Lagonda Cleaners can give you. Write us for the catalog and full details.

LAGONDA



CLEANERS
FOR TUBES OF ALL TYPES AND SIZES

The Lagonda Mfg. Co.
SPRINGFIELD, OHIO.
FUEL SAVING SPECIALISTS
NEW YORK, CHICAGO, PHILADELPHIA, BOSTON, PITTSBURGH, CLEVELAND CINCINNATI, DETROIT, SYRACUSE, BALTIMORE.
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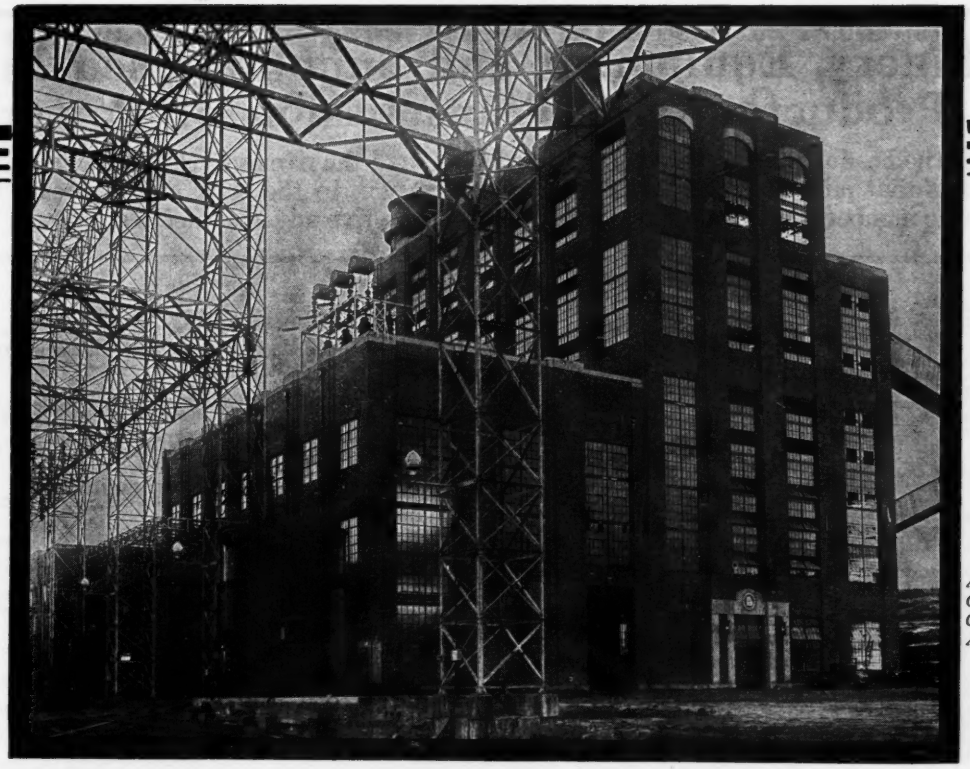

Atkinson Plant, Georgia Power Company, Atlanta, Georgia.

HEAT INSULATIONS
"made to measure"

Heat insulation must be designed to meet exact conditions—if real efficiency is secured. In this Atlanta power plant (475 lbs. steam pressure, temperature 740° F.) CAREY 1½" thick Hi-Temp No. 12 and 2½" thick 85% Magnesia were applied on steam mains.

These and other CAREY Insulations, in various thicknesses and combinations, to fit conditions, are saving fuel for modern power plants all over the country.

CAREY experience, aided by unsurpassed research facilities, has developed profitable answers to many heat insulation problems.

The recommendations of our engineering staff are at your service, if you will advise us the conditions to be met.

Carey HEAT INSULATIONS

For every need . . . from residence to super power plant

THE PHILIP CAREY COMPANY,— *Lockland,* CINCINNATI, OHIO

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

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National Tube Co., Pittsburgh.

BELT CONVEYORS
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Fairfield Engineering Co., Marion, Ohio.
Jeffrey Mfg. Co., Columbus.
Link-Belt Co., Chicago, Ill.

BELT DRESSING
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany, N. Y.

BELTING, SILENT CHAIN
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE
Air Preheater Corp., New York.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Prat-Daniel Corp., New York.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT
Sturtevant Co., B. F., Boston.
Wing Mfg. Co., L. J., New York.

BLOWERS, PORTABLE
Sturtevant Co., B. F., Boston.
Wing Mfg. Co., L. J., New York.

BLOWERS, PRESSURE
Wing Mfg. Co., L. J., New York.

BLOWERS, PULVERIZED COAL
Wing Mfg. Co., L. J., New York.

BLOWERS, STEAM
Schutte & Koerting Co., Phila.

BLOWERS, TUBE
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Corp., Detroit, Mich.
Vulcan Soot Cleaner Co., Dubois, Pa.

BLOWERS, TURBINE
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLE CONTRACTORS
Boiler Engrg. Co., Newark, N. J.
Engineer Co., The, New York.

BOILER BAFFLES
Boiler Engrg. Co., Newark, N. J.
Engineer Co., The, New York.
McLeod & Henry Co., Troy, N. Y.
Quigley Co. Inc., New York.

BOILER BLOW-DOWN SYSTEMS
Henszey De-Concentrator Co., Watertown, Wis.

BOILER CAP CLEANERS
Lagonda Mfg. Co., Springfield, O.

BOILER COMPOUND
Dearborn Chemical Co., Chicago.
Economy Lubricating Co., Charlestown, Mass.
Garratt-Callahan Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.

BOILER ENGINEERS
Boiler Engrg. Co., Newark, N. J.

BOILER FEED WATER, PURIFYING APPARATUS
Griscom-Russell Co., New York.

BOILER FRONTS
McLeod & Henry Co., Troy, N. Y.

BOILER SETTING CEMENT
Babcock and Wilcox Co., New York.
Harbison-Walker Refract. Co., Pittsburgh, Pa.

BOILER SETTINGS
Ballard, Sprague & Co., Inc., New York, N. Y.
Engineer Co., The, New York.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Rust Engrg. Co., Pittsburgh.

BOILER TUBE CAPS
Key Boiler Equip. Co., E. St. Louis, Ill.

BOILER TUBE CLEANERS
General Specialty Co., Buffalo.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

BOILER TUBES
Bethlehem Steel Co., Bethlehem, Pa.
National Tube Co., Pittsburgh.

BOILERS
Babcock and Wilcox Co., New York.
Badenhausen Corp., Cornwells Heights, Pa.
Combustion Engrg. Corp., N. Y.
Connelly Boiler Co., The D., Cleveland, O.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Wks., Burlington, Ia.
Nuway Boiler & Engrg. Co., Chicago, Ill.
Springfield Boiler Co., Springfield, Ill.
Union Iron Wks., Erie, Pa.
Wickes Boiler Co., Saginaw.

BOILERS, HEATING
Babcock and Wilcox Co., New York.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Springfield Boiler Co., Springfield, Ill.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 150

BOILERS, RETURN TUBULAR
Erie City Iron Works, Erie, Pa.
Murray Iron Wks., Burlington, Ia.

BOILERS, SEMI-PORTABLE
Erie City Iron Works, Erie, Pa.

BOILERS, WASTE HEAT
Babcock and Wilcox Co., New York.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Wickes Boiler Co., Saginaw.

BOILERS, WATER TUBE
Babcock and Wilcox Co., New York.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Murray Iron Wks., Burlington, Ia.
Springfield Boiler Co., Springfie'd, Ill.
Wickes Boiler Co., Saginaw.

BREECHINGS
Connery & Co., Inc., Phila.

BRICKS, FURNACE LINING
Norton Co., Worcester, Mass.

BRUSHES, DYNAMO AND MOTOR
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

BUCKET ELEVATORS
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Brady Conveyors Corp., Chicago.
Fairfield Engineering Co., Marion, Ohio.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.

BUCKETS, COAL HANDLING
Jeffrey Mfg. Co., Columbus, O.

CABLE JOINTS
Associated Engineers Co., Chicago.

CABLE RACKS
Associated Engineers Co., Chicago.

CAR DUMPERS
Wellman Eng'rg. Co., Cleveland.

CARRIERS, PIVOTED BUCKET
Jeffrey Mfg. Co., Columbus, O.

CASTINGS
Fuller Lehigh Co., Fullerton, Pa.
Neemes F'dry. Inc., Troy, N. Y.

CASTINGS, STEEL
Springfield Boiler Co., Springfield, Ill.

CEMENT, ACID PROOF
Quigley Co. Inc., New York.

CEMENT, FURNACE
Babcock and Wilcox Co., New York.
Harbison - Walker Refract. Co., Pittsburgh.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.

CEMENT GUNS
Cement Gun Co., Inc., Allentown, Pa.

CEMENT, HIGH TEMPERATURE
Babcock and Wilcox Co., New York.
Harbison - Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Quigley Co. Inc., New York.

CEMENT, IRON
Smooth-On Mfg. Co., Jersey City.

CEMENT, REFRACTORY
Babcock and Wilcox Co., New York.
Quigley Co. Inc., New York.

CHAIN WHEELS
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHEMICALS, WATER TREATING
Mohawk Water Treatment Co., Cleveland.
National Aluminate Corp., Chicago, Ill.

CHIMNEYS
American Chimney Corp., N. Y.
Ballard, Sprague & Co., N. Y.
Rust Engrg. Co., Pittsburgh.

CIRCUIT BREAKERS
I-T-E Circuit Breaker Co., Philadelphia, Pa.

CLEANING COMPOUND
Dearborn Chem. Co., Chicago.

COAL AND ASH-HANDLING MACHINERY
Allen-Sherman-Hoff Co., Phila.
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Brady Conveyors Corp, Chicago.
Detrick Co., M. H., Chicago.
Fairbanks, Morse & Co., Chicago.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago.

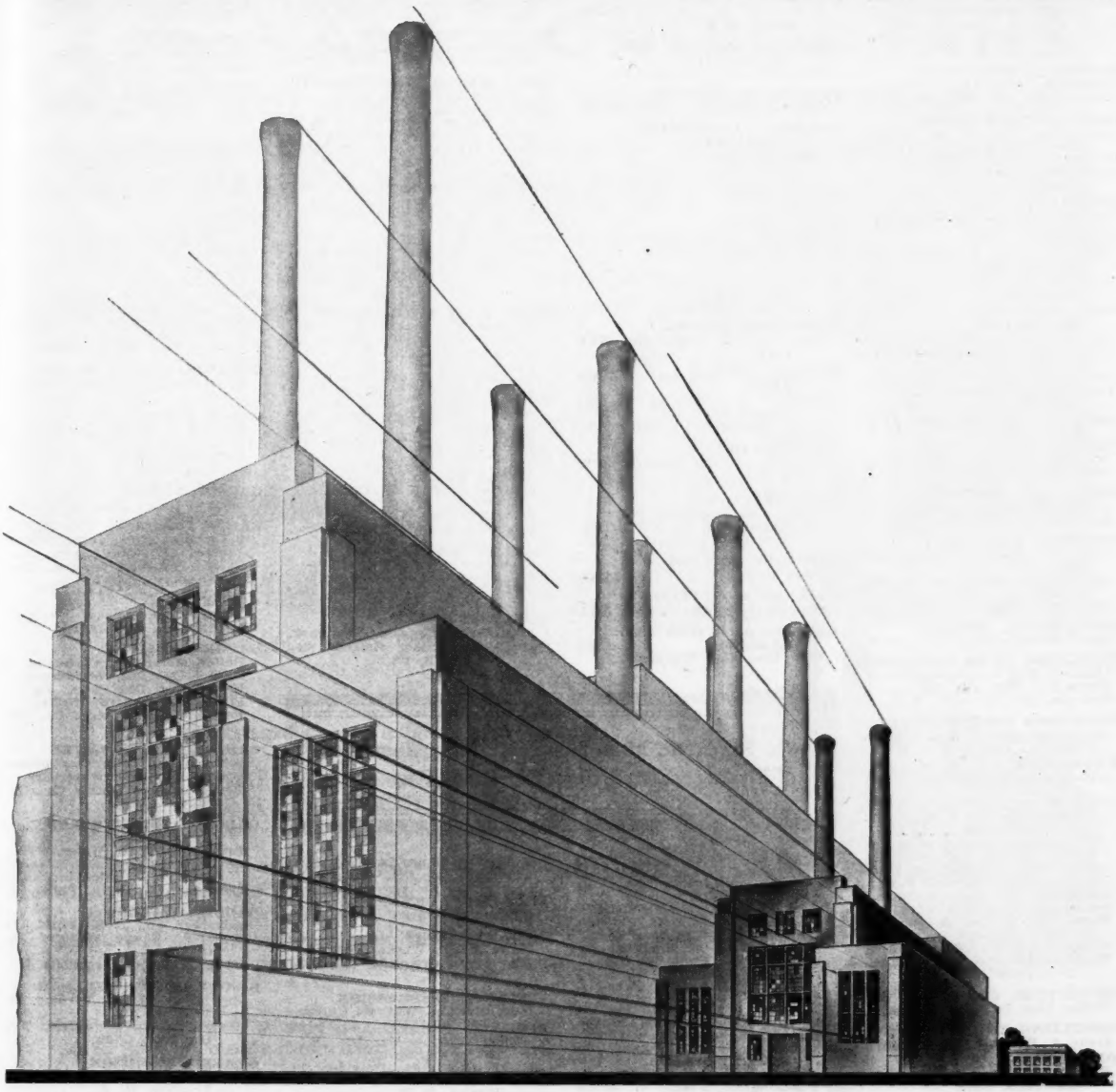
COAL BUNKERS, CAST IRON, CATENARY
Allen-Sherman-Hoff Co., Phila.

COAL CARBONIZING APPARATUS
Combustion Engrg. Corp., N. Y.

COAL CRUSHERS
American Pulverizer Co., St. Louis.
Bartlett & Snow Co., The C. O Cleveland, Ohio.
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., Columbus, O.
Pennsylvania Crusher Co., Phila.
Strong - Scott Mfg. Co., Minneapolis, Minn.

COAL STORAGE EQUIPMENT
Allen-Sherman-Hoff Co., Phila.
Brady Conveyors Corp, Chicago.
Link-Belt Company, Chicago.

BUILDERS *and* ENGINEERS *For The* BUSINESS LEADERS *of* AMERICA



TO MEET YOUR FUTURE NEEDS

Comprehensive study of present conditions and future trends made in co-operation with clients' engineering departments, provide a basis for accurate forecast of market growth.

Stone & Webster Engineering Corporation offers 40 years' experience in the generation, transmission, and distribution of power both in design and construction.

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INCORPORATED

Sauerman Bros., Inc., Chicago.
Wellman Eng'rg. Co., Cleveland.

COAL WEIGHING AND MEASURING EQUIPMENT
C. J. Mfg. Co., Philadelphia.
Richardson Scale Co., Clifton, N. J.

COATINGS, PROTECTIVE
Dampney Co. of Am., Boston.
Quigley Co. Inc., New York.

COCKS, AIR AND STEAM
Dart Mfg. Co., E. M., Providence, R. I.
Powell Co., Wm., Cincinnati.
Williams Valve Co., D. T., Cincinnati.

COILS AND BENDS
Badger & Sons Co., E. B., Boston.
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Pipe Bending Co., New Haven, Conn.

COMBUSTION (CO_2) RECORDERS
Brown Inst. Co., Phila., Pa.
Leeds and Northrup Co., Philadelphia.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago, Ill.

COMBUSTION CONTROL SYSTEMS
Bailey Meter Co., Cleveland.
Engineer Co., New York, N. Y.
Leeds & Northrup Co., Phila.

COMBUSTION ENGINEERS
Boiler Eng'r'g Co., Newark, N. J.
Engineer Co., The, New York.

COMPOUND PIPE JOINT
Dixon Crucible Co., Jos., Jersey City, N. J.
Key Boiler Equip. Co., E. St. Louis, Ill.
Smooth-On Mfg. Co., Jersey City.

COMPRESSORS, THERMO
Croll Reynolds Eng'r'g Co., N. Y.

CONDENSER TUBE CLEANERS
Lagonda Mfg. Co., Springfield, O.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

CONDENSER TUBE SERVICE
Condenser Service & Engineering Co., Hoboken, N. J.

CONDENSERS
Allis-Chalmers Mfg. Co., Milwaukee, Wisc.
Binks Mfg. Co., Chicago, Ill.
Condenser Service & Engineering Co., Hoboken, N. J.
Croll Reynolds Eng'r'g Co., N. Y.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Ingersoll-Rand Co., New York.
Schutte & Koerting Co., Phila.
Superheater Co., New York.
Westinghouse, Elec. & Mfg. Co., East Pittsburgh, Pa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

CONNECTORS, COPPER
Burke Elec. Co., Erie, Penna.

CONSULTING ENGINEERS
Stone & Webster, Inc., Boston.

CONVEYORS
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Brady Conveyors Corp, Chicago.
Detrick Co., M. H., Chicago.
Fairfield Engineering Co., Marion, Ohio.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Richardson Scale Co., Clifton, N. J.

COOLERS, OIL
Griscom-Russell Co., New York City.
Schutte & Koerting Co., Phila.
Wheeler Mfg. Co., C. H., Phila.

COOLING SYSTEMS
Badger & Sons Co., E. B., Boston.
Binks Mfg. Co., Chicago, Ill.
Marley Co., The, Kansas City.
Sturtevant Co., B. F., Boston.
Yarnall-Waring Co., Phila.

COOLING TOWERS
Foster Wheeler Corp., New York.
Marley Co., Kansas City, Mo.
Wheeler Mfg. Co., C. H., Phila.

COUNTERS, REVOLUTION
Lonergan Co., J. E., Phila., Pa.

COUPLINGS, COMPRESSION SHAFT
Nicholson & Co., W. H., Wilkes-Barre, Pa.

COUPLINGS, FLEXIBLE
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Terry Steam Turbine Co., The, Hartford, Conn.

COUPLINGS AND JOINTS
Grinnell Co., Inc., Providence.

COUPLINGS, UNION
Dart Mfg. Co., E. M., Providence, R. I.

CRANES, CRAWLING AND LOCOMOTIVE
Link-Belt Co., Chicago, Ill.

CRANES, TRAVELING
Wellman Eng'rg. Co., Cleveland.

CRUSHING & GRINDING MACHINERY
American Pulverizer Co., St. Louis.

DEAERATORS
Elliott Co., Jeannette, Pa.

DE-CONCENTRATOR
Henszey De-Concentrator Co., Watertown, Wis.

DESIGNERS & BUILDERS, POWER PLANT
Stone & Webster, Inc., Boston.

DESUPERHEATERS
Babcock and Wilcox Co., New York.

DRYERS, ROTARY AND WASTE HEAT
Bartlett & Snow Co., C. O., Cleveland, O.
Fuller Lehigh Co., Fullerton, Pa.

ECONOMIZERS
Babcock & Wilcox Co., New York.
Foster Wheeler Corp., N. Y.

EJECTORS
Elliott Co., Jeannette, Pa.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

EJECTORS, SEWAGE
Nash Engrg. Co., S. Norwalk.

ELECTRICAL SUPPLIES
Gen. Electric Co., Schenectady.

ELECTRICAL WIRES AND CABLES
Gen. Elec. Co., Schenectady.

FANS, EXHAUST AND VENTILATING
Coppus Engrg. Corp., Worcester.
Sturtevant Co., B. F., Boston.
Wing Mfg. Co., L. J., New York.

FEED WATER FILTERS
Elgin Softener Corp., Elgin, Ill.
Filtrators Co., Inc., New York.

FEED WATER HEATERS AND PURIFIERS
Cochrane Corp., Philadelphia.
Croll Reynolds Eng'r'g Co., N. Y.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Griscom-Russell Co., New York.
Hoppes Mfg. Co., Springfield, O.
National Pipe Bending Co., New Haven, Conn.
Scaife & Sons Co., Wm. B., Oakmont, Pa.
Schutte & Koerting Co., Phila.
Superheater Co., The, New York.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

FEED WATER TREATMENT
Dearborn Chemical Co., Chicago.
Elgin Softener Corp., Elgin, Ill.
Filtrators Co., Inc., New York.
Garratt-Callahan Co., Chicago.
Griscom-Russell Co., New York.
Mohawk Water Treatment Co., Cleveland.
National Aluminate Corp., Chicago, Ill.
Scaife & Sons Co., Wm. B., Oakmont, Pa.

FILTERS, OIL
Bowser & Co., S. F., Ft. Wayne, Ind.
Burt Mfg. Co., The, Akron, O.
Nugent & Co., Wm. W., Chicago.

FILTERS, WATER
Cochrane Corp., Philadelphia.
Filtrators Co., Inc., New York.
Scaife & Sons Co., Wm. B., Oakmont, Pa.

FIRE BRICK
Babcock & Wilcox Co., New York.
Harbison - Walker Refract. Co., Pittsburgh, Pa.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 150

ELIMINATORS, AUTO, STEAM
Nicholson & Co., W. H., Wilkes-Barre, Pa.

ENGINES, GAS AND GASOLINE
Fairbanks, Morse & Co., Chicago.
Ingersoll-Rand Co., New York.
Sterling Eng. Co., Buffalo.
Worthington Pump & Mach. Corp., New York.

ENGINES, OIL
Bethlehem Steel Co., Bethlehem.
Fairbanks, Morse & Co., Chicago.
Ingersoll-Rand Co., New York.
Morris & De La Vergne, Inc., I. P., Philadelphia.
Sterling Eng. Co., Buffalo.
Worthington Pump & Mach. Corp., New York.

ENGINES, PUMPING
Murray Iron Wks., Burlington, Ia.

ENGINES, STEAM
Allis - Chalmers Mfg. Co., Milwaukee, Wis.
Elliott Co., Jeannette, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Wks., Burlington, Ia.
Sturtevant Co., B. F., Boston.
Troy Eng. & Mach. Co., Troy, Pa.
Wachs Co., E. H., Chicago.

ENGINE STOPS, AUTOMATIC
Strong Carlisle & Hammond Co., Cleveland.

EVAPORATORS
Croll Reynolds Eng'r'g Co., N. Y.
Foster Wheeler Corp., New York.
Griscom-Russell Co., New York City.

EXHAUST HEADS
Burt Mfg. Co., The, Akron, O.
Direct Separator Co., Syracuse.
Hoppes Mfg. Co., Springfield, O.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Watson & McDaniel Co., Phila.
Wright-Austin Co., Detroit, Mich.

EXPANDERS, TUBE
Nicholson & Co., W. H., Wilkes-Barre, Pa.

FANS, ELECTRIC
Coppus Engrg. Corp., Worcester.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., S., Chicago.

FIRE BRICK CEMENT
McLeod & Henry Co., Troy, N. Y.

FIRE HYDRANTS
Howard Iron Works, Buffalo.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.

FITTINGS, COMPRESSION
Nugent & Co., Wm. W., Chicago.

FITTINGS, FLANGE AND PIPE
Fisher Governor Co., Inc., Marshalltown, Iowa.
Grinnell Co., Inc., Providence.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Limbert & Co., Geo. B., Chicago.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.

FLANGES
Dart Mfg. Co., E. M., Providence, R. I.
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.

FLOATS
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Reliance Gauge Column Co., Cleveland.

FLOW METERS
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., Phila., Pa.
Republic Flow Meters Co., Chicago, Ill.

FLUE CLEANERS
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Co., Detroit, Mich.
General Specialty Co., Buffalo.
Liberty Mfg. Co., Jeannette Pa.
Pierce Co., Wm. B., Buffalo.
Vulcan Soot Cleaner Co., Du Bois, Pa.

FURNACE BOTTOMS, CAST IRON, AIR-COOLED
Allen-Sherman-Hoff Co., Phila.

FURNACE FIRE OBSERVERS
Springfield Boiler Co., Springfield, Ill.

FURNACE SURFACES, WATER COOLED
Foster Wheeler Corp., New York.
Fuller Lehigh Co., Fullerton, Pa.
Superheater Co., New York.

FURNACE WALLS
Combustion Engrg. Corp., N. Y.
Superheater Co., New York.

FURNACES
Erie City Iron Works, Erie, Pa.
Riley Stoker Corp., Worcester.

FURNACES, WATER COOLED
Erie City Iron Works, Erie, Pa.

GAS PRODUCERS
Wellman Eng'rg. Co., Cleveland.

GASKETS
Crandall Packing Co., Palmyra, N. Y.
Darcoid Co., Inc., New York.
Flexitallic Gasket Co., Camden, N. J.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Metallo Gasket Co., New Brunswick, N. J.
Smooth-On Mfg. Co., Jersey City.

GASKETS, ASBESTOS, STEEL
Flexitallic Gasket Co., Camden, N. J.

GAUGE COCKS
H. Belfield Co., Philadelphia, Pa.
Lonergan Co., J. E., Phila., Pa.
Reliance Gauge Column Co., Cleveland.

GAUGE GLASSES
Jenkins Bros., New York, N. Y.

GAUGE TESTERS
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
Fisher Governor Co., Inc., Marshalltown, Iowa.

GAUGES
Condenser Service & Engineering Co., Hoboken, N. J.

GAUGES, DRAFT
Bailey Meter Co., Cleveland, O.
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago.

GAUGES, LIQUID LEVEL
Boiler Room Impr. Co., Chicago.
Bristol Co., The, Waterbury.
Republic Flow Meters Co., Chicago.

GAUGES, PRESSURE AND RECORDING
Bristol Co., The, Waterbury.
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
Lonergan Co., J. E., Phila., Pa.

GAUGES, WATER
Lonergan Co., J. E., Phila., Pa.
Reliance Gauge Column Co., Cleveland.
Yarnall-Waring Co., Phila.

GEARS, DOUBLE HELICAL
De Laval Steam Turbine Co., Trenton, N. J.
Terry Steam Turbine Co., The, Hartford, Conn.

GEARS, REDUCTION
De Laval Steam Turbine Co., Trenton, N. J.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

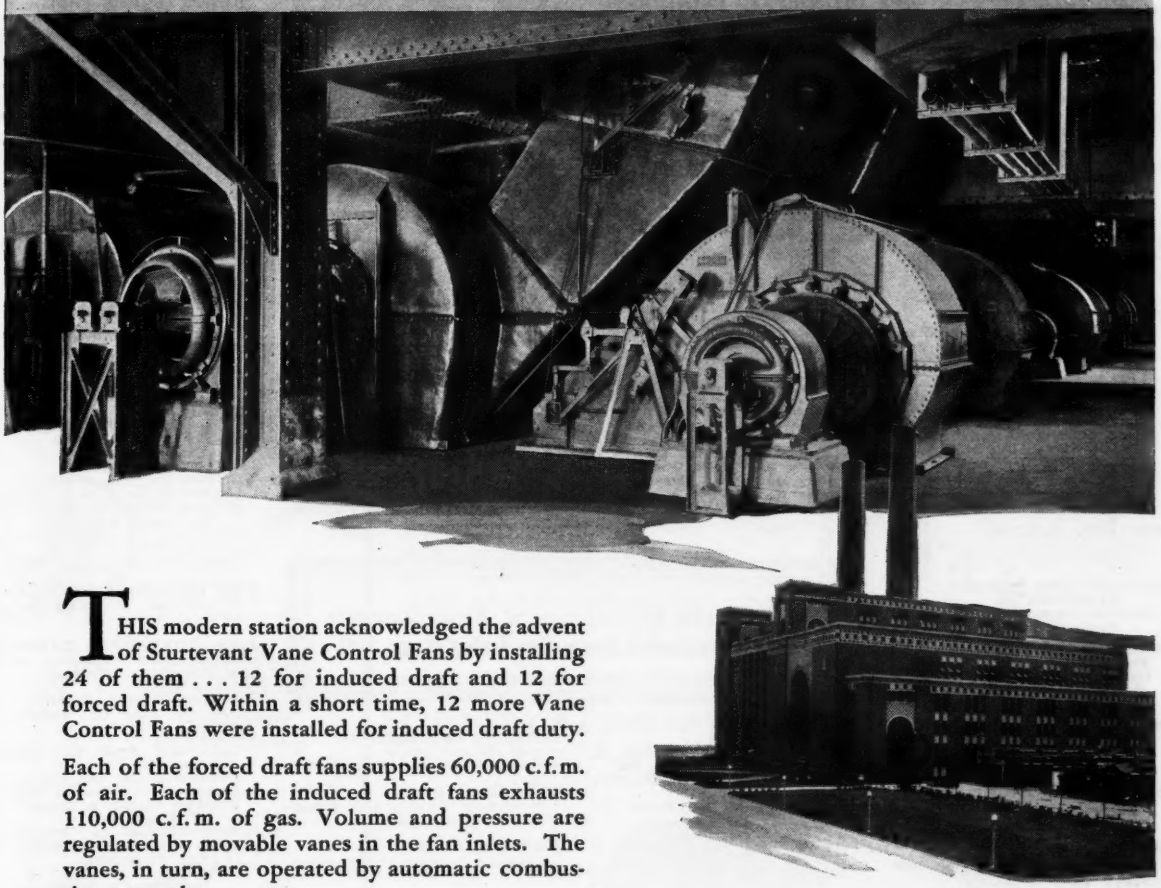
GENERATING SETS
Allis - Chalmers Mfg. Co., Milwaukee, Wis.
Burke Elec. Co., Erie, Penna.
Fairbanks, Morse & Co., Chicago.
Moore Steam Turbine Corp., Wellsville, N. Y.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GENERATORS, ELECTRIC
Allis - Chalmers Mfg. Co., Milwaukee, Wis.
Burke Elec. Co., Erie, Penna.
Elliott Co., Jeannette, Pa.
Gen. Elec. Co., Schenectady.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GOVERNORS, ENGINE
Pickering Governor Co., Portland, Conn.

GOVERNORS, PUMP
Atlas Valve Co., Newark, N. J.
Chapin-Fulton Mfg. Co., The, Pittsburgh.
D'Este Co., Julian, Boston.

36 VANE CONTROL FANS at the State Line Generating Co.



THIS modern station acknowledged the advent of Sturtevant Vane Control Fans by installing 24 of them . . . 12 for induced draft and 12 for forced draft. Within a short time, 12 more Vane Control Fans were installed for induced draft duty.

Each of the forced draft fans supplies 60,000 c.f.m. of air. Each of the induced draft fans exhausts 110,000 c.f.m. of gas. Volume and pressure are regulated by movable vanes in the fan inlets. The vanes, in turn, are operated by automatic combustion control.

Sturtevant Vane Control Fans assure a saving of 20 to 30% in motor input over ordinary damper regulation, and large savings over slip-ring motor control. In addition, expensive slip-ring motor control is eliminated.

This is the only type of mechanical draft fan that does not require a higher motor input with squirrel-cage motors and damper control than with slip-ring motors and speed control.

Sturtevant Vane Control Fans have proved their advantages in public utilities and industrial plants throughout the country. It would be a pleasure to send you complete data.

State Line Generating Co., Hammond, Ind.
Engineers: Sargent & Lundy, Inc.

B. F. STURTEVANT COMPANY
Main Offices: HYDE PARK, BOSTON, MASS.—CHICAGO, ILL., 410 No. Michigan Ave.—SAN FRANCISCO, CAL., 681 Market St.
Branch Offices in Principal Cities. Canadian Offices at: Toronto, Montreal and Galt. Canadian Rep: Kipp Kelly, Ltd., Winnipeg.

Sturtevant *Vane Control Fans*
REG. U.S. PAT. OFF.

STEAM TURBINES~FORCED AND INDUCED DRAFT FANS~ELECTRIC MOTORS
FUEL ECONOMIZERS~GENERATING SETS~AIR PREHEATERS

Fisher Governor Co., Inc., Marshalltown, Iowa.
Mercon Regulator Co., Chicago.
Northern Equipment Co., Erie, Pa.
Pickering Governor Co., Portland, Conn.
Squires Co., C. E., Cleveland.
Watson & McDaniel Co., Phila.
Wright-Austin Co.

GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

GRATE BARS
Flynn & Emrich Co., Baltimore.

GRATES
Flynn & Emrich Co., Baltimore.
Kelly Foundry & Mach. Co., Goshen, Ind.
Neemes Fdry., Inc., Troy, N. Y.

GREASE
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Phila.
Standard Oil Co. (Indiana), Chicago, Ill.
Vacuum Oil Co., New York.

GREASE CUPS
(See Oil and Grease Cups.)

GUNS, CEMENT
Quigley Co. Inc., New York.

GUNS, REFRACTORY
Cement Gun Co., Inc., Allentown, Pa.
Quigley Co. Inc., New York.

HEAT EXCHANGERS
Babcock & Wilcox Co., New York.
Croll Reynolds Eng'r'g Co., N. Y.
Elgin Softener Corp., Elgin, Ill.
Foster Wheeler Corp., New York.
Griscom-Russell Co., New York.
National Pipe Bending Co., New Haven, Conn.
Superheater Co., New York.
Wheeler Mfg. Co., C. H., Phila.

HEATERS, BLEEDER
Foster Wheeler Corp., New York.
Griscom-Russell Co., New York.

HEATERS FOR SPECIAL PURPOSES
National Pipe Bending Co., New Haven, Conn.

HEATERS, HOT WATER
Foster Wheeler Corp., New York.
Griscom-Russell Co., New York.
National Pipe Bending Co., New Haven, Conn.

HEATERS, OIL
National Pipe Bending Co., New Haven, Conn.
Wheeler Mfg. Co., C. H., Phila.

HEATERS, STORAGE
National Pipe Bending Co., New Haven, Conn.

HOISTS
Sullivan Machinery Co., Chicago.

HOISTS, SKIP
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Brady Conveyors Corp, Chicago.
Fairfield Engineering Co., Marion, Ohio.
Link-Belt Co., Chicago, Ill.

HOPPERS AND BINS, COAL AND ASH
Allen-Sherman-Hoff Co., Phila.
Brady Conveyors Corp, Chicago.
Connery & Co., Inc., Phila.

HYDROMETERS
Taylor Instr. Co's., Rochester.

HYDRODIEKS
Taylor Instr. Co's., Rochester.

ICE MAKING AND REFRIGERATING MACHINERY
Ingersoll-Rand Co., New York.
Taylor Instr. Co's., Rochester.

INDICATORS, ENGINE
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

INJECTORS AND INSPIRATORS
Schutte & Koerting Co., Phila.
Superheater Co., The, New York.

INSTRUMENTS, ELECTRICAL
Gen. Elec. Co., Schenectady.
Leeds & Northrup Co., Phila.

INSULATING MATERIAL
Carey Co., Philip, Cincinnati.
Gen. Elec. Co., Schenectady.

INSULATORS, MOLDED
Burke Elec. Co., Erie, Penna.

JOINTS, EXPANSION
Badger & Sons Co., E. B., Boston.
Foster Wheeler Corp., New York.
Howard Iron Works, Buffalo.
Sharon Co., R. W., Pittsburgh.
Wheeler Mfg. Co., C. H., Phila.
Yarnall Waring Co., Phila.

LABORATORY, FURNACE
Babcock & Wilcox Co., New York.

LINING, FURNACE
Norton Co., Worcester, Mass.

LININGS, COAL BUNKER
Wailes Dove-Hermiston Corp., New York, N. Y.

LOADERS AND UNLOADERS
Brady Conveyors Corp, Chicago.
Fairfield Engineering Co., Marion, Ohio.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago, Ill.

LUBRICANTS
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Economy Lubricating Co., Charlestown, Mass.
Keystone Lubricating Co., Phila.
Standard Oil Co. (Indiana), Chicago, Ill.
Vacuum Oil Co., New York.

LUBRICATORS
Bowser & Co., S. F., Ft. Wayne, Ind.
Keystone Lubricating Co., Phila.
Nugent & Co., Wm. W., Chicago.
Powell Co., Wm., Cincinnati.
Stephenson Mfg. Co., Albany, N. Y.
Williams Valve Co., D. T., Cincinnati.

MECHANICAL DRAFT APPARATUS
Coppus Engrg. Corp., Worcester.
Sturtevant Co., B. F., Boston.
Wing Mfg. Co., L. J., New York.

METERS, AIR AND GAS
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Republic Flow Meters Co., Chicago.

METERS, BOILER
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., Phila., Pa.
Republic Flow Meters Co., Chicago.
Yarnall-Waring Co., Phila.

METERS, COAL
Bailey Meter Co., Cleveland, O.
C. J. Mfg. Co., Philadelphia.
Republic Flow Meters Co., Chicago.

METERS, FEED WATER
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago.
Worthington Pump & Mach. Corp., New York.
Yarnall-Waring Co., Philadelphia.

METERS, STEAM
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., Phila., Pa.
Builders Iron Fdry., Providence.
Republic Flow Meters Co., Chicago.

METERS V NOTCH
Yarnall-Waring Co., Phila.

METERS, WATER
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago.

MOTORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Burke Elec. Co., Erie, Penna.
Fairbanks, Morse & Co., Chicago.
Gen. Elec. Co., Schenectady.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

NOZZLES FOR ALL PURPOSES
Binks Mfg. Co., Chicago, Ill.
Marley Co., Kansas City, Mo.
Schutte & Koerting Co., Phila.
Yarnall-Waring Co., Philadelphia.

OIL AND GREASE CUPS
Keystone Lubricating Co., Phila.
Lonergan Co., J. E., Phila., Pa.
Williams Valve Co., D. T., Cincinnati.

OIL BURNING EQUIPMENT
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Engineer Co., New York, N. Y.
Peabody Engrg. Corp., N. Y.
Schutte & Koerting Co., Phila.

OIL, COAL, GAS BURNER
Engineer Co., New York, N. Y.
Peabody Engrg. Corp., N. Y.

OIL PURIFIERS
Bowser & Co., S. F., Ft. Wayne, Ind.
De Laval Separator Co., N. Y.
De Laval Steam Turbine Co., Trenton, N. J.
Nugent & Co., Wm. W., Chicago.

OIL SEPARATORS
De Laval Separator Co., N. Y.
Elliott Co., Jeannette, Pa.
Nugent & Co., Wm. W., Chicago.
Wright-Austin Co., Detroit, Mich.

OIL STORAGE EQUIPMENT
Bowser & Co., S. F., Ft. Wayne, Ind.

OIL TANKS
Bowser & Co., S. F., Ft. Wayne, Ind.
Nugent & Co., Wm. W., Chicago.

OILING SYSTEMS
Bowser & Co., S. F., Ft. Wayne, Ind.
Burt Mfg. Co., The, Akron, O.
De Laval Separator Co., N. Y.
Nugent & Co., Wm. W., Chicago.

OILS, LUBRICATING
Dearborn Chemical Co., Chicago.
Standard Oil Co. (Indiana), Chicago, Ill.
Vacuum Oil Co., New York.

PACKING, ASBESTOS
Crandall Packing Co., Palmyra, N. Y.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 150

PACKING, CENTRIFUGAL PUMP
Crandall Pkg. Co., Palmyra, N. Y.

PACKING, FIBRE
Condenser Service & Engineering Co., Hoboken, N. J.

PACKING, FLAX
Crandall Packing Co., Palmyra, N. Y.

PACKING, METALLIC
Condenser Service & Engineering Co., Hoboken, N. J.
Crandall Pkg. Co., Palmyra, N. Y.
Crane Packing Co., Chicago.

PACKING, METALLIC FOR CONDENSER TUBES
Crane Packing Co., Chicago.

PACKING, PISTON AND ROD
Crandall Pkg. Co., Palmyra, N. Y.
Crane Packing Co., Chicago.
Darcoid Co., Inc., New York.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.

PACKING, SHEET
Crandall Packing Co., Palmyra, N. Y.
Darcoid Co., Inc., New York.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Jenkins Bros., New York, N. Y.

PACKING, VALVE STEM
Crandall Pkg. Co., Palmyra, N. Y.
Darcoid Co., Inc., New York.

PAINT, ACID, ALKALI AND WATER RESISTANT
Quigley Co. Inc., New York.

PAINT, ANTI-CORROSIVE
Wailes Dove-Hermiston Corp., New York, N. Y.

PAINT, FLOOR
Wailes Dove-Hermiston Corp., New York, N. Y.

PAINT, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

PAINT, HEAT RESISTING
Wailes Dove-Hermiston Corp., New York, N. Y.

PAINT, PROTECTIVE
Wailes Dove-Hermiston Corp., New York, N. Y.

PATCHING MATERIAL, REFRACTORY
Quigley Co. Inc., New York.

PIPE BENDING
Badger & Sons Co., E. B., Boston.
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.

PIPE CLAMPS, COUPLINGS AND JOINTS
Grinnell Co., Inc., Providence.

PIPE COILS
Badger & Sons Co., E. B., Boston.
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.
Superheater Co., The, New York.

PIPE COVERINGS
Carey Co., Philip, Cincinnati.

PIPE CUTTERS
Toledo Pipe Threading Mach. Co., The, Toledo, O.

PIPE FABRICATORS
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.

PIPE HANGERS & SUPPLIES
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.

PIPE THREADING MACHINES
Toledo Pipe Threading Mach. Co., The, Toledo, O.

PIPE, WROUGHT STEEL
National Tube Co., Pittsburgh.

PIPING
Bethlehem Steel Co., Bethlehem, Pa.
Connery & Co., Inc., Phila.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Tube Co., Pittsburgh.
Pittsburgh Piping & Equipment Co., Pittsburgh.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.

PIPING CONTRACTING MANUFACTURERS
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.

PORTABLE CONVEYORS
Jeffrey Mfg. Co., Columbus, O.

POWER PLANT MANAGEMENT
Stone & Webster, Inc., Boston.

POWER SHOWS
Midwestern Eng'g. Exposition, Inc., Chicago, Ill.

PREHEATERS
Babcock & Wilcox Co., New York.

PROTECTIVE COATINGS
Quigley Furnace Specialties Co., Inc., New York City.

PULVERIZED COAL BURNERS
Erie City Iron Works, Erie, Pa.
Fuller Lehigh Co., Fullerton, Pa.

PULVERIZED COAL FEEDERS
Fuller Lehigh Co., Fullerton, Pa.

PULVERIZED FUEL EQUIPMENT
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Erie City Iron Works, Erie, Pa.
Foster Wheeler Corp., N. Y.
Fuller Lehigh Co., Fullerton, Pa.

---and the trend still continues to specification of CONNERY'S CONSTRUCTION

Here are reproduced a few of the famous names and trade-marks that are found on products coming from plants in which Connery Construction serves. Known throughout the world of industry and power for costing no more than ordinary construction, yet giving long, tight service. Connery's records show years of performance with outstanding economy.

This construction has been installed more recently in such plants as the American Salpa Corp., Bureau of Standards Plant, Deepwater Station, American Enka Corp., Lever Bros. Plant, American Glanzstoff Corp., and many others.

Connery Construction provides for maximum contraction and expansion, without sliding joints, for boiler breechings, smoke flues, uptakes, air ducts and preheater ducts. It will not buckle, warp or collapse; it is gas-tight and moisture-proof.

Let us bid on your next job.

CONNERY & COMPANY, INC.
4000 North Second St., Philadelphia, Pa.
Branch Office: New York

Gold Medal awarded to Connery & Company at the Philadelphia Sesqui-Centennial "For Improved Expansion Compensating and Stiffened draft flues and dampers."

Other Connery Users Include:

Rhinelander Paper Co.
Atmospheric Nitrogen Co.
English Station
Philo Station—2nd Unit
By-Products Coke Corp.
Texas Gulf Sulphur
Seal Beach—Addition

Kennedy-Van Saun Mfg. & Eng. Corp., New York, N. Y.
Riley Stoker Corp., Worcester.

PULVERIZERS, COAL
American Pulverizer Co., St. Louis.
Bartlett & Snow Co., C. O., Cleveland, O.
Bethlehem Steel Co., Bethlehem, Pa.
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., The, Columbus.
Kennedy-Van Saun Mfg. & Eng. Corp., New York, N. Y.
Pennsylvania Crusher Co., Phila.
Riley Stoker Corp., Worcester.
Strong-Scott Mfg. Co., Minneapolis, Minn.

PUMPING SYSTEMS, AIR LIFT
Ingersoll-Rand Co., New York.
Sullivan Machinery Co., Chicago.

PULVERIZERS, LIMESTONE
American Pulverizer Co., St. Louis.
Fuller Lehigh Co., Fullerton, Pa.

PUMPS
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, BOILER FEED
Allis-Chalmers Mfg. Co., Milwaukee, Wisc.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Fairbanks, Morse & Co., Chicago.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Ingersoll-Rand Co., New York.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Lecourtenay Co., Newark, N. J.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Machy. Corp., New York.

PUMPS, CENTRIFUGAL
Allis - Chalmers Mfg. Co., Milwaukee, Wis.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Fairbanks, Morse & Co., Chicago.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Ingersoll-Rand Co., New York.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
La Bour Co., Inc., Elkhart, Ind.
Lecourtenay Co., Newark, N. J.
Moore Steam Turbine Corp., Wellsville, N. Y.
Nash Engrg. Co., S. Norwalk.
Terry Steam Turbine Co., Hartford, Conn.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

PUMPS, DEEP WELL
Fairbanks, Morse & Co., Chicago.
Westco - Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Mach. Corp., New York.

PUMPS, ELECTRIC
Frederick Iron & Steel Co., Frederick, Md.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, ELEVATOR AND FIRE
De Laval Steam Turbine Co., Trenton, N. J.
Frederick Iron & Steel Co., Frederick, Md.
Lecourtenay Co., Newark, N. J.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, GENERAL SERVICE
Frederick Iron & Steel Co., Frederick, Md.
Nash Engrg. Co., S. Norwalk.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, HYDRAULIC PRESSURE
Frederick Iron & Steel Co., Frederick, Md.
Warren Steam Pump Co., Inc., Warren, Mass.

PUMPS, JET
Croll Reynolds Eng'r'g Co., N. Y.

PUMPS, OIL
Frederick Iron & Steel Co., Frederick, Md.
Lonergan Co., J. E., Phila, Pa.
Nugent & Co., Wm. W., Chicago.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, POWER
Fairbanks, Morse & Co., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Lecourtenay Co., Newark, N. J.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Mach. Corp., New York.

PUMPS, PULVERIZED COAL
Fuller Lehigh Co., Fullerton, Pa.

PUMPS, ROTARY
Wheeler Mfg. Co., C. H., Phila.

PUMPS, TURBINE
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.

PUMPS, VACUUM
Allen & Billmyre Co., Inc., N. Y.
Foster Wheeler Corp., New York.
Ingersoll-Rand Co., New York.
Nash Engrg. Co., S. Norwalk.
Sullivan Machy. Co., Chicago.
Warren Steam Pump Co., Inc., Warren, Mass.
Wheeler Mfg. Co., C. H., Phila.

PUMPS, WATERWORKS
Fairbanks, Morse & Co., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Lecourtenay Co., Newark, N. J.
Moore Steam Turbine Corp., Wellsville, N. Y.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PURIFIERS, BOILER FEED
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Scaife & Sons Co., Wm. B., Oakmont, Pa.

PURIFIERS, STEAM
Marley Co., Kansas City, Mo.

PYROMETERS
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Leeds & Northrup Co., Phila.
Republic Flow Meters Co., Chicago, Ill.
Superheater Co., The, N. Y.
Taylor Instr. Co's., Rochester.

QUENCHERS, ASH
Allen - Sherman - Hoff Co., The, Philadelphia, Pa.

RECORDERS, LIQUID LEVEL
Bristol Co., The, Waterbury.

RECORDERS, PRESSURE
Crosby Steam Gage & Valve Co., Boston.

RECORDING INSTRUMENTS
Bristol Co., The, Waterbury.
Leeds and Northrup Co., Philadelphia.
Taylor Instr. Co's., Rochester.

REFRACTORIES
Harbison - Walker Refract. Co., Pittsburgh.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Quigley Co. Inc., New York.
Rust Engrg. Co., Pittsburgh.

REGULATORS, DAMPER
Atlas Valve Co., Newark, N. J.
Brown Inst. Co., Phila., Pa.
D'Este Co., Julian, Boston.
Engineer Co., New York, N. Y.
Kieley & Mueller, Inc., New York.
Ruggles-Klingemann Mfg. Co., Salem, Mass.

REGULATORS, EXCESS PRESSURE
Mercon Regulator Co., Chicago.

REGULATORS, FAN ENGINE
Atlas Valve Co., Newark, N. J.

REGULATORS, FEED WATER
Atlas Valve Co., Newark, N. J.
Bailey Meter Co., Cleveland.
Chaplin-Fulton Mfg. Co., Pittsburgh.
Mercon Regulator Co., Chicago.
Northern Equipment Co., Erie, Pa.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York.
Squires Co., C. E., Cleveland.
Wright-Austin Co., Detroit, Mich.

REGULATORS, PRESSURE
D'Este Co., Julian, Boston.
Fisher Governor Co., Inc., Marshalltown, Iowa.
Kieley & Mueller, Inc., New York.
Mercon Regulator Co., Chicago.
Northern Equipment Co., Erie, Pa.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York, N. Y.
Squires Co., C. E., Cleveland.
Strong Carlisle & Hammond Co., Cleveland.
Watson & McDaniel Co., Phila.

REGULATORS, PUMP
Mercon Regulator Co., Chicago.

REGULATORS, TEMPERATURE
Atlas Valve Co., Newark, N. J.
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
D'Este Co., Julian, Boston.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York, N. Y.
Taylor Instr. Co's., Rochester.

RESUPERHEATERS
Babcock & Wilcox Co., New York.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 150

ROPE DRESSING AND PRESERVATIVE
Stephenson Mfg. Co., Albany, N. Y.

RUST PREVENTIVES
Dearborn Chem. Co., Chicago.

SCALE REMOVERS (Mechanical)
General Specialty Co., Buffalo.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

SCALES, COAL
Richardson Scale Co., Clifton, N. J.

SCRAPERS, DRAG
Sauerman Bros., Inc., Chicago.

SEPARATORS AND EXTRACTORS, STEAM AND OIL
Cochrane Corp., Philadelphia.
D'Este Co., Julian, Boston.
Direct Separator Co., Syracuse.
Hoppes Mfg. Co., Springfield, O.
Kieley & Mueller, Inc., New York.
Marley Co., Kansas City, Mo.
National Pipe Bending Co., The, New Haven, Conn.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Strong Carlisle & Hammond Co., Cleveland.
Williams Valve Co., D. T., Cincinnati.
Wright-Austin Co., Detroit, Mich.

SEPARATORS, STEAM AND AIR
Nicholson & Co., W. H., Wilkes-Barre, Pa.

SHAFTING
National Tube Co., Pittsburgh.

SLUICING SYSTEMS, ASH
Allen-Sherman-Hoff Co., Phila.
Brady Conveyors Corp, Chicago.

SMOKE INDICATORS
Boiler Room Impr. Co., Chicago.

SODIUM ALUMINATE
National Aluminate Corp., Chicago, Ill.

SOOT BLOWERS
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Corp., Detroit, Mich.
Vulcan Soot Cleaner Co., Dubois, Pa.

SPEED RECORDERS
Leeds and Northrup Co., Philadelphia.

SPEED REDUCERS, CHAIN
Morse Chain Co., Ithaca, N. Y.

SPRAY AIR WASHERS
Badger & Sons Co., E. B., Boston.
Binks Mfg. Co., Chicago, Ill.

SPRAY COOLING SYSTEMS
Badger & Sons Co., E. B., Boston.
Binks Mfg. Co., Chicago, Ill.
Marley Co., The, Kansas City, Mo.
Yarnall-Waring Co., Phila.

SPRAY NOZZLES
Marley Co., Kansas City, Mo.
Yarnall-Waring Co., Phila.

SPROCKET RIMS
Babbitt Steam Specialty Co., New Bedford, Mass.

STACKS, METAL
Connery & Co., Inc., Phila.

STEAM TRAPS
Armstrong Machine Wks., Three Rivers, Mich.
Cochrane Corp., Philadelphia.
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
D'Este Co., Julian, Boston.
Fisher Governor Co., Inc., Marshalltown, Iowa.
Kaye & MacDonald, Inc., West Orange, N. J.
Kieley & Mueller, Inc., New York.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Reliance Gauge Column Co., Cleveland.
Sarco Company, Inc., New York.
Squires Co., C. E., Cleveland.
Strong Carlisle & Hammond Co., Cleveland.
Watson & McDaniel Co., Phila.
Williams Valve Co., D. T., Cincinnati.
Wright-Austin Co., Detroit, Mich.

STEEL, ALLOY
Bethlehem Steel Co., Bethlehem, Pa.

STEEL, STAYBOLT & ENGINE BOLT
Bethlehem Steel Co., Bethlehem, Pa.

STOCKS AND DIES
Toledo Pipe Threading Mach. Co., The, Toledo, O.

STOKERS
Babcock & Wilcox Co., New York.

STOKERS, CHAIN GRATE
Combustion Engrg. Corp., N. Y.
Riley Stoker Corp., Worcester.

STOKERS, HAND OPERATED
CoKal Stoker Corp., Chicago.
Flynn & Emrich Co., Baltimore.
Kelly Foundry & Mach. Co., The, Goshen, Ind.

STOKERS, MECHANICAL
American Engrg. Co., Phila.
CoKal Stoker Corp., Chicago.
Combustion Engrg. Corp., N. Y.
Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore.
Riley Stoker Corp., Worcester.

STOKERS, OVERFEED
CoKal Stoker Corp., Chicago.
Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore.
Riley Stoker Corp., Worcester.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

STOKERS, UNDERFEED
American Engrg. Co., Phila.
Combustion Engrg. Corp., N. Y.
Detroit Stoker Co., Detroit.
Riley Stoker Corp., Worcester.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

STRAINERS
Sarco Co., Inc., New York.
Strong Carlisle & Hammond Co., Cleveland.

STRAINERS, OIL
Sarco Co., Inc., New York.

SUPERHEATERS
Babcock and Wilcox Co., New York.

SUPERHEATERS, STEAM
Babcock & Wilcox Co., New York.
Badenhausen Corp., Cornwells Heights, Pa.

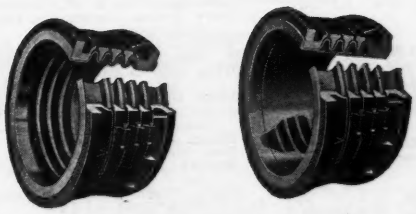
BADGER JOINT DEVELOPMENTS

Seamless tube of special copper for making corrugations.

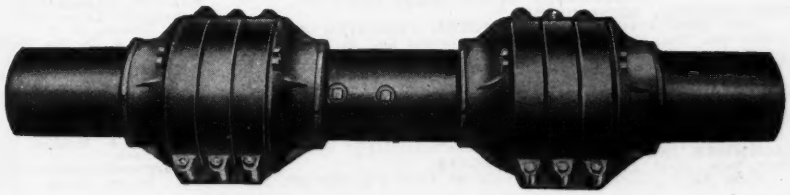
Self-equalizing rings.

Monel Metal sleeve for superheated steam.

Welding-end joint.



Welding-end and Flanged-end Joints. Small cut at right shows Monel Metal sleeve for use with superheated steam.



Badger Popularity is Based on Results of Badger Developments

IN the long history back of the Badger Expansion Joint, nothing was copied—except possibly the use of corrugations for taking up line movements. This idea is so obvious that it is everyone's idea.

But starting with this, Badger developed and perfected feature after feature.

When you buy Badger Joints you are buying joints made by engineers who know explicitly just why certain features are incorporated.

This is your assurance that the joint is right.

Standard welding-end and flanged-end joints are available up to 30" in diameter.

E. B. BADGER & SONS COMPANY

71 Pitts Street, Boston, Mass.

BRANCHES

Atlanta, Georgia, Red Rock Bldg.
Charlotte, N. C., 1408 Independence Building
Chicago, Ill., 2831 South Parkway
Cincinnati, Ohio, Union Trust Bldg.
Cleveland, Ohio, Guardian Bldg.
Detroit, Mich., 402 Ford Bldg.
Houston, Tex., 1308 Sec. Nat. Bk. Bldg.
Indianapolis, Ind., 823 Occidental Bldg.
Kansas City, Mo., 1336 Oak Street
Los Angeles, Cal., 517 Hollingsworth Building
Minneapolis, Minn., 732 Build. Exch.
Montreal, Que., Can. Cement Bldg.
New Orleans, La., 419 Maritime Bldg.
New York City, 271 Madison Ave.
Philadelphia, Pa., 1500 Walnut St. Room 901
Pittsburgh, Pa., Union Trust Bldg.
Salt Lake City, Utah, Kearns Bldg.
San Francisco, Cal., Sharon Bldg.
Seattle, Wash., 415 Lenora Street
St. Louis, Mo., 3605 Laclede Ave.

BADGER EXPANSION JOINTS

Foster Wheeler Corp., N. Y.
Marley Co., The, Kansas City, Mo.
Superheater Co., The, New York.

SWITCHES, DISCONNECT
Associated Engineers Co., Chicago.

TACHOMETERS
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

TANKS
Connery & Co., Inc., Phila.
Scaife & Sons, Wm. B., Oakmont, Pa.

TELESCOPIC OILERS
Nugent & Co., Wm. W., Chicago.

TERMINAL, BLOCKS
Burke Elec. Co., Erie, Penna.

THERMOCOUPLES
Leeds and Northrup Co., Philadelphia.

THERMOMETERS
Bristol Co., The, Waterbury.
Condenser Service & Engineering Co., Hoboken, N. J.
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
Leeds and Northrup Co., Philadelphia.
Taylor Instr. Co's., Rochester.

THERMOMETERS, RECORDING AND INDICATING
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
Leeds and Northrup Co., Philadelphia.
Taylor Instr. Co's., Rochester.

TRACKWORK, INDUSTRIAL
Bethlehem Steel Co., Bethlehem, Pa.

TRANSFORMERS, BONDING
Associated Engineers Co., Chicago.

TRAPS, BLAST
Strong Carlisle & Hammond Co., Cleveland.

TRAPS, COMPRESSED AIR
Armstrong Machine Wks., Three Rivers, Mich.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

TRAPS, OIL & GREASE
Strong Carlisle & Hammond Co., Cleveland.

TRAPS, RETURN
D'Este Co., Julian, Boston.
Kieley & Mueller, Inc., New York.
Sarco Co., Inc., New York.

TRAPS, STEAM & RADIATOR
Armstrong Machine Wks., Three Rivers, Mich.
Sarco Co., Inc., New York.
Strong, Carlisle & Hammond Co., Cleveland.

TRAPS, VACUUM
Armstrong Machine Wks., Three Rivers, Mich.
Strong Carlisle & Hammond Co., Cleveland.

TUBING
National Tube Co., Pittsburgh.
Pittsburgh Steel Products Co., Pittsburgh, Pa.

TUBING, CONDENSER
Condenser Service & Engineering Co., Hoboken, N. J.

TUBING, SEAMLESS STEEL
Pittsburgh Steel Products Co., Pittsburgh, Pa.

TUBE CUTTERS
Lagonda Mfg. Co., Springfield, O.

TUBES, BOILER, CHARCOAL IRON
Bethlehem Steel Co., Bethlehem, Pa.

TUBING, CONDENSER
Foster Wheeler Corp., N. Y.

TUBING, SEAMLESS STEEL
National Tube Co., Pittsburgh.

TURBINES, HYDRAULIC
Allis-Chalmers Mfg. Co., Milwaukee, Wisc.
DeLaval Steam Turbine Co., Trenton, N. J.
Morris & De La Vergne, Inc., I. P., Philadelphia.

TURBINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
DeLaval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannette, Pa.
Gen. Elec. Co., Schenectady.
Moore Steam Turbine Co., Wellsville, N. Y.
Murray Iron Wks., Burlington, Ia.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburg, Pa.
Wing Mfg. Co., L. J. New York.

TURBO GENERATORS
Allis-Chalmers Mfg. Co., Milwaukee, Wisc.
Elliott Co., Jeannette, Pa.
Gen. Elec. Co., Schenectady.
Murray Iron Wks., Burlington Ia.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

UNIONS
Atlas Valve Co., Newark, N. J.
Dart Mfg. Co., E. M., Providence, R. I.
Edward Valve & Mfg. Co., East Chicago, Ind.

VACUUM CLEANING SYSTEMS
Sturtevant Co., B. F., Boston.

VALVE DISCS
Goetze Gasket & Packing Co., New Brunswick, N. J.
Jenkins Bros., New York, N. Y.
Metallo Gasket Co., New Brunswick, N. J.

VALVES
Atlas Valve Co., Newark, N. J.

VALVES, FLOAT
Atlas Valve Co., Newark, N. J.
Crosby Steam Gage & Valve Co., Boston.
Fisher Governor Co., Inc., Marshalltown, Iowa.
Kieley & Mueller, Inc., New York.
Yarnall-Waring Co., Philadelphia.

VALVES, GATE
Crosby Steam Gage & Valve Co., Boston.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Powell Co., Wm., Cincinnati.
Walworth Co., Boston.
Williams Valve Co., D. T., Cincinnati.

VALVES, GLOBE
H. Belfield Co., Philadelphia, Pa.
Crosby Steam Gage & Valve Co., Boston.
Edward Valve & Mfg. Co., East Chicago, Ind.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Powell Co., Wm., Cincinnati.
Strong Carlisle & Hammond Co., Cleveland.
Williams Valve Co., D. T., Cincinnati.

VALVES, HYDRAULIC
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Morris & De La Vergne, Inc., I. P., Philadelphia.
Yarnall-Waring Co., Phila.

VALVES, NON-RETURN
Edward Valve & Mfg. Co., East Chicago, Ind.
Kieley & Mueller, Inc., New York.
Ruggles-Klingemann Mfg. Co., Salem, Mass.

VALVES, REGULATING
Atlas Valve Co., Newark, N. J.
H. Belfield Co., Philadelphia, Pa.
Mercon Regulator Co., Chicago.
Northern Equipment Co., Erie, Pa.

VALVES, RELIEF
Cochrane Corp., Philadelphia.
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
Crosby Steam Gage & Valve Co., Boston.
Edward Valve & Mfg. Co., East Chicago, Ind.
Fisher Governor Co., Inc., Marshalltown, Iowa.
Lonergan Co., J. E., Phila., Pa.
Mercon Regulator Co., Chicago.

VALVES, SIGHT FEED
Nugent & Co., Wm. W., Chicago.

VALVES, STEEL
Edward Valve & Mfg. Co., East Chicago, Ind.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Powell Co., Wm., Cincinnati.

VALVES, STOP
Crosby Steam Gage & Valve Co., Boston.
Edward Valve & Mfg. Co., East Chicago, Ind.
Schutte & Koerting Co., Phila.

VALVES, THREE AND FOUR WAY
Nicholson & Co., W. H., Wilkes-Barre, Pa.

VENTILATING APPARATUS
Badger & Sons Co., E. B., Boston.
Burt Mfg. Co., The, Akron, O.
Coppus Engrg. Corp., Worcester.
Sturtevant Co., B. F., Boston.
Wing Mfg. Co., L. J., New York.

WASTE HEAT RECOVERY SYSTEMS
Babcock & Wilcox Co., New York.
Edge Moor Iron Co., Edge Moor.

WATER BACKS, HIGH & LOW PRESSURE
Foster Wheeler Corp., New York.

WATER COLUMNS AND ALARMS
Reliance Gauge Column Co., The, Cleveland, O.
Wright-Austin Co.
Yarnall-Waring Co., Phila.

WATER COOLING EQUIPMENT
Marley Co., The, Kansas City, Mo.
Wright-Austin Co., Detroit, Mich.
Yarnall-Waring Co., Philadelphia.

WATER PURIFYING APPARATUS
Elgin Softener Corp., Elgin, Ill.

WATER SOFTENING SYSTEMS
Cochrane Corp., Philadelphia.
Dearborn Chemical Co., Chicago.
Elgin Softener Corp., Elgin, Ill.
Griscom-Russell Co., New York.
National Aluminate Corp., Chicago, Ill.
Scaife & Sons, Wm. B., Oakmont, Pa.

WATER TESTING EQUIPMENT
National Aluminate Corp., Chicago, Ill.

WATER WALLS
Edge Moor Iron Co., Edge Moor.
Fuller Lehigh Co., Fullerton, Pa.
Springfield Boiler Co., Springfield, Ill.

WEIGH LARRIES
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Richardson Scale Co., Clifton, N. J.

WEIGHING, MACHINERY
Richardson Scale Co., Clifton, N. J.

WELDED HEADERS
Grinnell Co., Providence, R. I.
Midwest Piping & Supply Co., St. Louis, Mo.

WHISTLES
Lonergan Co., J. E., Phila., Pa.
Powell Co., Wm., Cincinnati.

WRENCHES
Condenser Service & Engineering Co., Hoboken, N. J.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 150

Condenser Service & Engineering Co., Hoboken, N. J.
Edward Valve & Mfg. Co., East Chicago, Ind.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Powell Co., Wm., Cincinnati.

VALVES, ALTITUDE
Kieley & Mueller, Inc., New York.

VALVES, AUTOMATIC CUT-OFF
Elliott Co., Jeannette, Pa.
Fisher Governor Co., Inc., Marshalltown, Iowa.

VALVES, AUTOMATIC STOP AND CHECK
Edward Valve & Mfg. Co., East Chicago, Ind.
Ruggles-Klingemann Mfg. Co., Salem, Mass.

VALVES, BLOW-OFF
Crosby Steam Gage & Valve Co., Boston.
Edward Valve & Mfg. Co., East Chicago, Ind.
Everlasting Valve Co., Jersey City, N. J.
Jenkins Bros., New York, N. Y.
Powell Co., Wm., Cincinnati.
Yarnall-Waring Co., Phila.

VALVES, BY-PASS
Jenkins Bros., New York, N. Y.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.

VALVES, CHECK
Crosby Steam Gage & Valve Co., Boston.
Edward Valve & Mfg. Co., East Chicago, Ind.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Powell Co., Wm., Cincinnati.
Schutte & Koerting Co., Phila.
Williams Valve Co., D. T., Cincinnati.
Schutte & Koerting Co., Philadelphia.

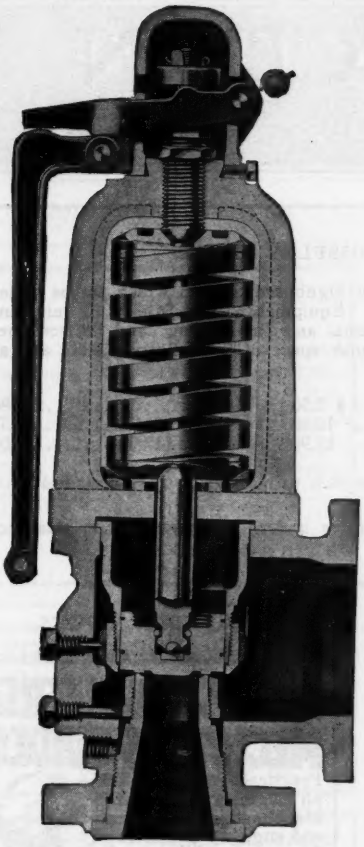
VALVES, POP SAFETY
Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.
Crosby Steam Gage & Valve Co., Boston.
Lonergan Co., J. E., Phila., Pa.

VALVES, PUMP
Combination Pump Valve Co., Philadelphia.
Crosby Steam Gage & Valve Co., Boston.
Fisher Governor Co., Inc., Marshalltown, Iowa.
Jenkins Bros., New York, N. Y.

VALVES, RADIATOR
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Sarco Co., Inc., New York.
Williams Valve Co., D. T., Cincinnati.

VALVES, REDUCING
Atlas Valve Co., Newark, N. J.
H. Belfield Co., Philadelphia, Pa.
Chapin-Fulton Mfg. Co., Pittsburgh, Pa.
D'Este Co., Julian, Boston.
Fisher Governor Co., Inc., Marshalltown, Iowa.
Kieley & Mueller, Inc., New York.
Mercon Regulator Co., Chicago.
Northern Equipment Co., Erie, Pa.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Squires Co., C. E., Cleveland, O.
Strong Carlisle & Hammond Co., Cleveland.
Watson & McDaniel Co., Phila.

VALVES, REGRINDING
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Powell Co., Wm., Cincinnati.
Williams Valve Co., D. T., Cincinnati.



CROSBY NOZZLE SAFETY VALVES

3. Inlet Nozzle FORGED in one piece from alloy steel entirely top guided

Crosby Nozzle Safety Valves embody the latest advance in design and valve construction. They can be found on the boilers and superheaters in the great public utility stations and in the most progressive high pressure industrial plants.

The nozzle is theoretically correct in its design and proportions. It is a cone affording maximum strength. It is symmetrical and will therefore not distort under changes of pressure and temperature. It is free from obstructions and permits smooth flow without eddy currents.

The nozzle is FORGED from high nickel chrome steel, a material of great strength and resistance to corrosion and erosion, which properties are greatly increased by the refined grain resulting from forging.

The joint between the boiler outlet and the safety valve is made directly against the one piece nozzle of the valve. There are no threads under pressure.

Advantages

1. Smooth operation.
2. Maximum relieving capacity.
3. Inlet nozzle FORGED in one piece from alloy steel. No threads under pressure.
4. Symmetrical valve disc FORGED from alloy steel entirely top guided.
5. Knife-edge seat—easily kept tight.
6. Bearing between spindle and disc is a hardened steel ball and bushing.
7. Valve body contoured for smooth, unobstructed flow.
8. Spring of low stress and air cooled.
9. Finer adjustment, knife-edge contact and even disc loading eliminate warn.
10. Low maintenance.

CROSBY
Screwed
Tube Gage

Interesting bulletin giving full particulars will be sent upon request.

Crosby Steam Gage & Valve Company

Makers of Safety and Relief Valves, Indicating and Recording Gages, Gage Testing Equipment, Blow-off, Globe, Angle and Check Valves, Steam Engine Indicators, Chime Whistles, etc.

Boston Chicago
New York London

SIGNBOARD SECTION

Quick Action Opportunities

CLASSIFIED RATES

Advertisements in the Signboard Section which come under the classification "Position Wanted," "Help Wanted," "Salesmen and Agencies," "Business Opportunities," "Patents and Patent Attorneys" and "Technical Books" will be set in type as shown below and published at the rate of

50 cents a line

each insertion, 6 words to a line; minimum sold, 4 lines.

For display of any advertisement under the classified headings see sizes and rates in column at right.

DISPLAY RATES

Advertisements in Signboard Section which comes under the classification "Equipment for Sale," "Equipment Wanted," "Educational and Instruction," and "Miscellaneous" are set in display space of the following sizes and at these rates:

1 in.	$ 5.50	4 in.	$20.80
2 in.	10.80	1 col. (8½ in.)	43.35
3 in.	15.90	2 col. (17 in.)	85.00

Not less than one inch to be sold in these classifications.

For advertising rates under other headings in this section, see column at left.

SALESMEN AND AGENCIES

New York City Representation

The Sales Agent of the Coppus Engineering Corporation (formerly their Sales, Export and Advertising Manager) wishes to handle additional account.

G. H. BOLLE,

120 Liberty St., Room 505, New York City.

SALES ENGINEERS. Boston. Well established, desire power plant equipment account. Salary and commission or commission and part expenses. Address Box 1079, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

PITTSBURGH, PA., REPRESENTATIVE AVAILABLE — Sales Engineer over fifteen years' contact with Engineering and Purchasing Departments in the Pittsburgh industrial district invites correspondence with reliable manufacturers having product of proven merit who desire competent representation in this territory. Address Box 1077, Power Plant Engineering, 53 W. Jackson Blvd., Chicago.

LONG ESTABLISHED New England manufacturer, contemplating expansion program with national advertising, for a successful, high-grade industrial lubricating grease and boiler treatment, desires experienced salesmen or manufacturers' agents outside New England on commission or special arrangement. Write full particulars in confidence, to Box 1075, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

MANUFACTURERS AGENTS, established 1926, selling pumps, industrial and power plant equipment in Detroit territory; desire one or two additional lines. Address Box 1074, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

SALESMEN WANTED—Mfg. of only exclusive semi-metallic packing on the market desires experienced packing salesmen or men familiar with engineering trade as state representatives and salesmen. Give full references. Box 1072, Power Plant Engineering, 53 W. Jackson Blvd., Chicago.

ENGINEERS WANTED

WANTED—Chief Operating Power Engineer in medium sized industrial plant in Middle West. Please give age, experience and salary expected. Reply to Box 1078, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

POSITIONS WANTED

MECHANICAL OR EXECUTIVE ENGINEER. University graduate, 35, married; broad experience with central station and industrial plants. Experience includes plant surveys for power and heat, recommendations for improvements, estimating cost and savings; complete design of power plants, supervision of construction, operation and maintenance. Box 1069, Power Plant Engineering, 53 W. Jackson Blvd. Chicago, Ill.

LICENSED FIREMAN—20 years' experience, wants opportunity, preferably in Detroit or Chicago, but will go anywhere. A man who will pitch in and do any sort of general power plant or maintenance work. Write to Box 1071, Power Plant Engineering, 53 W. Jackson Blvd., Chicago.

POSITION WANTED. Engineer and Machinist. Expert on Diesel engine erection, maintenance, and operation. Twenty years experience in Europe. Address Box 1060, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

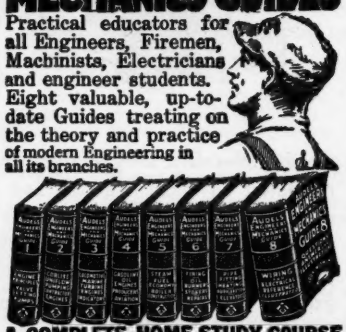
PATENT ATTORNEYS

PATENTS—Booklet free. Highest references. Best results. Promptness assured. Send drawing or model. WATSON E. COLEMAN, Registered Patent Lawyer, 724 9th Street, Washington, D. C.

TECHNICAL BOOKS

AUDELS ENGINEERS & MECHANICS GUIDES

Practical educators for all Engineers, Firemen, Machinists, Electricians and engineer students. Eight valuable, up-to-date Guides treating on the theory and practice of modern Engineering in all its branches.



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INFORMATION: — *In A Handy Form.* Answers to Your Questions and Problems. Here is a partial list of the subjects covered:— **Engine Principles, Valve Setting, Pumps, Corliss Engines, Uniflow Engines, Pumping Engines, Contractors Engines, Locomotives, Marine Engines, Turbine Engines, Gas Engines, Oil Engines, Indicators, Producers, Aviation, Steam, Fuel Economy, Boiler Construction, Firing, Oil Burners, Stokers, Boiler Repairs, Pipe Fitting, Heating, Refrigeration, Elevators, Dynamos, Motors, Lighting, Wiring, Electrical Diagrams, Radio, Electrical Reference and Calculations.**

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Not a cent to pay until you see the books. No obligation to buy unless you are satisfied. Fill in coupon *in pencil.* Send now—today—get this standard library for Engineers and Mechanics.

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Theo. Audel & Co., 65 W. 23 St., N.Y. City

Send me AUDELS ENGINEERS AND MECHANICS GUIDES. 8 numbers, $12, for *free examination.* If satisfactory, I will send you $1 in 7 days, then $1 monthly until $12 is paid.

Name.....

Address.....

Occupation.... .....

Employed by..... **P.P.E.**

SIGNBOARD SECTION

Quick Action Opportunities

EQUIPMENT WANTED

WANTED

150-K.W. Westinghouse compound interpole 250-VDC. generator, 1200-RPM., direct connected to 225-HP. Westinghouse synchronous motor 80% P.F., 2200-volts, 3-phase, 60-cycle, with all panel and starting equipment.

T. B. MacCABE,
2230 W. Lippincott St.,
Philadelphia, Pa.

EQUIPMENT WANTED
Used—In Good Condition

One Turbine Generator, 1500 K.W. 80 P.F. 3 phase, 60 cycle, 2400 volt, with surface condenser and auxiliaries.

BOARD OF PUBLIC WORKS
409 Vine St., Poplar Bluff, Mo.

Wanted, a 75 K.W. Generator

D. C. 125 to 250 volt, 3 wire system connected to a modern high speed engine, of economical operation. To operate at 100 lbs. initial steam pressure with 2 to 5 lbs. back pressure. Any machine offered for our inspection must be in Massachusetts or nearby.

MASSACHUSETTS REFORMATORY,
C. T. Judge, Supt.,
West Concord, Massachusetts.

EQUIPMENT FOR SALE

FOR SALE

1 Allis-Chalmers 18x42 Corliss engine, girder frame, 72 R.P.M., heavy split belt wheel 14 ft. in diameter, 26" face.

1 Bates 14x36 Corliss engine, heavy duty, speed 115 R.P.M., two heavy split belt wheels 12 ft. in diameter 26" face and 8 ft. in diameter 30" face.

All in good condition. Can be shown operating up to January 1st.

OWOSSO CASKET COMPANY
Owosso, Michigan

FOR SALE

One Used Foster Wheeler Single Loop Superheater

Used on a 729 hp. water tube boiler, with 100 degrees superheat at 150% rating.

Write to Box 1068

POWER PLANT ENGINEERING
53 W. Jackson Blvd., Chicago, Ill.

EQUIPMENT FOR SALE

A. C. UNITS

780 KVA. Burke—24x30 Erie Ball 4 valve $6,000
500 KVA. C. W.—Chuse 4 valve.....$6000
500 KVA. G. E.—Ames Uniflow.....$7250
375 KVA. G. E.—Ridgeway 4 valve...$3000
250 KVA. & 125 KVA. Erie Ball 4 valve.
90 KVA. G. E.—14x14 Ames Uniflow.$1750

DIRECT CURRENT UNITS
75 to 500 KW. capacity.

BOILERS
250 to 800 HP. sizes.

MOTOR GENERATING SETS
15 to 500 KW. sizes.

POWER PLANT EQUIPMENT CO., Inc.
39-41 Cortlandt St., New York City, N. Y.

FOR SALE

One Skinner Unaflow Heavy Duty Engine direct connected to 250-KW. A. C. Generator, all in operating condition, Condenser included.

WATER & LIGHT UTILITY
Clay Center, Kansas

$2000 SAVED with Expenditure of $4
$6000 Generator showed complete ground on armature. If condition was not remedied by **TRIPLE E**

ELECTRIC CLEANING SOLUTION
a rewinding job would have been necessary. Use the Solution for Cleaning all Electsical Machines, Instruments, Apparatus, Motors and Generators- **ELECTRICAL ENGINEERING EQUIPMENT & CO., Dept.A, Long Island City.**

Volume I

ELECTRICITY

WHAT IT IS AND HOW IT ACTS

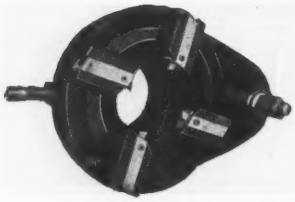
BY
ANDREW W. KRAMER

Associate Editor Power Plant Engineering, Associate Member American Institute of Electrical Engineers, Institute of Radio Engineers

288 pages, 5½ x 8, bound in maroon cloth, 130 illustrations, $2 postpaid

Published by

TECHNICAL PUBLISHING CO.
53 W. Jackson Blvd., Chicago



ONE PURPOSE—

—and that is to cut and thread pipe perfectly, efficiently.

"TOLEDO" Automatic pipe cutters are the fastest and most compact portable pipe cutters on the market. "TOLEDO" Automatics cut the pipe off square and without burr. The pipe is chamfered as it is cut, making it easy to start the threading tool. The knives are fed automatically. Simply a turn of the hand wheel and the knives begin to feed. Positive feed, no springs to become weak and cause trouble. Mechanically perfect.

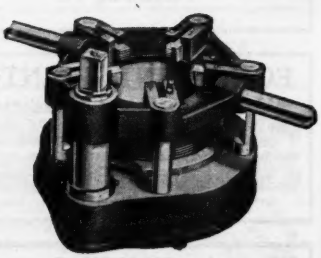
"TOLEDO" Geared Threading Devices all employ that well known "TOLEDO" receding die principle. They are geared and operate so easily that one man can cut a 12″ thread quickly by hand. When used with the "TOLEDO" power drive these tools are converted into fast efficient power equipment.

A post card brings full information on "TOLEDO" tools.

THE FINEST BEAR THIS TRADE-MARK IN THE LAND TRADE MARK

The TOLEDO PIPE THREADING MACH. CO.

TOLEDO, OHIO NEW YORK OFFICE, 72 LAFAYETTE ST.

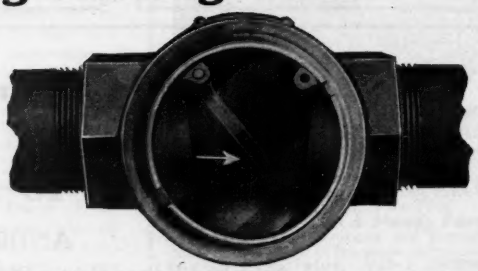


S & K FLOW INDICATORS

for pipe lines carrying cooling water

8 standard sizes, ½″ to 3″

Recommended for transformers, engine jackets, etc.



SCHUTTE KOERTING

Send for new Bulletin 6 F.

1156 Thompson Street
Philadelphia, Pa.

Pittsburgh Piping

MANUFACTURERS AND CONTRACTORS

WHEN YOU THINK OF PIPING THINK OF PITTSBURGH PIPING PP&EC

WE ARE fully equipped to supply fabricated materials and to install complete piping systems for Electric Power Stations, Blast Furnaces, Steel Mills, Coke Works and Industrial Plants of every description—backed by an experience of more than a quarter century.

PITTSBURGH PIPING & EQUIPMENT CO.

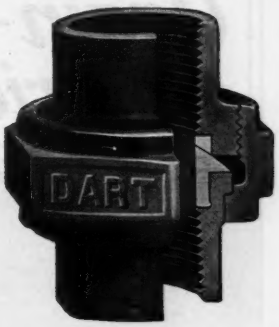
43rd St. and A. V. R. R., Pittsburgh, Pa.

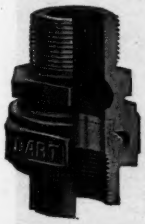
New York 220 Broadway — Chicago Peoples Gas Bldg. — San Francisco Call Bldg. — Cleveland Ulmer Bldg. — Houghton, Mich. Dee Bldg. — Indianapolis — Detroit Occidental Bldg. — General Motors Bldg. — Boston, 10 High St.

MODERN PIPE FABRICATION

MIDWEST PIPING & SUPPLY CO., Inc.
Main Office: St. Louis

35 years of service to the leading stations and industrial plants





Bringing security to joints in every pipe line through which fluids and gases flow, safety to men who work around them and continuity of service to the plant itself, Dart Unions are the choice of America's foremost industrial concerns.

Leak-tight under vibration and pressure, they are the great savers of media and pressures wherever used.

Once installed Dart Unions usually outlast the pipes they connect.

We give TWO Dart Unions for any ONE that proves defective in materials or workmanship.

Write today for Free Sample Union. Note the swedged-in, ground ball joints, **BOTH OF BRONZE,** and the sturdy maleable iron body and pipe ends. Catalogue "T" showing the complete Dart Line.

DART the 2-4-1 UNIONS

E. M. DART MANUFACTURING CO.
Providence, Rhode Island

Sales Agents: The Fairbanks Company, New York, and at All Branches
Canadian Factory: Dart Union Company, Ltd., Toronto, Canada

PIPE BENDS
WELDED HEADERS
CAST STEEL FITTINGS
COMPLETE POWER PLANT PIPING

A third of a century of piping leadership

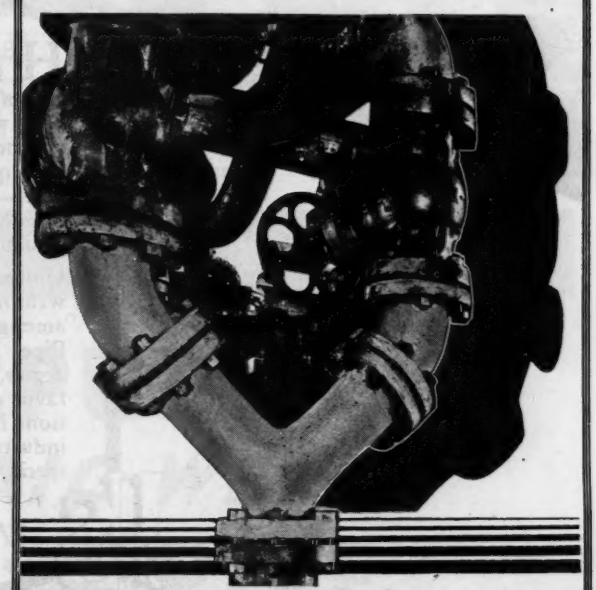
GEO. B. LIMBERT CO.
570 Fulton Street Chicago, Illinois

LIMBERT PIPING

SEVENTY-FIVE years' intimate experience with piping in all its phases is responsible for outstanding quality of Grinnell fabricating service.

GRINNELL COMPANY

Address inquiries to Providence, R. I.



PIPING - BY -

A pipe bend in a power plant, an exchanger in a refinery, a complete assembly of piping for conveying liquid or steam—no matter what the job may be, put it up to POWER PIPING COMPANY, Pittsburgh, Pa.

Power Piping

Again—the choice was America's Standard!

HERE is another installation of NATIONAL Pipe in a recently constructed power plant of one of America's leading industrial concerns. Engineers who design and erect the piping systems in many of the larger power plants of the country have been quick to recognize the advantages of using this pipe—it simplifies their erecting problems—facilitates completion of the job and gives additional assurance of a steady, smooth-running system.

Uniformity, strength, ductility, good threading and welding qualities and resistance to corrosion are among the outstanding characteristics of NATIONAL Pipe. Because it combines these advantages in unusual degree, this product has a commanding place in the favor of Power Engineers, whose consistent specifications have made it the most widely used pipe in this industry. For new plants, extensions or replacements specify NATIONAL—

America's Standard Wrought Pipe

NATIONAL TUBE COMPANY, Pittsburgh, Pa.
Subsidiary of United States Steel Corporation

US STEEL

NATIONAL PIPE

WELDED OR SEAMLESS

RECORD PRODUCTION TO MEET A RECORD DEMAND

You should know the facts—

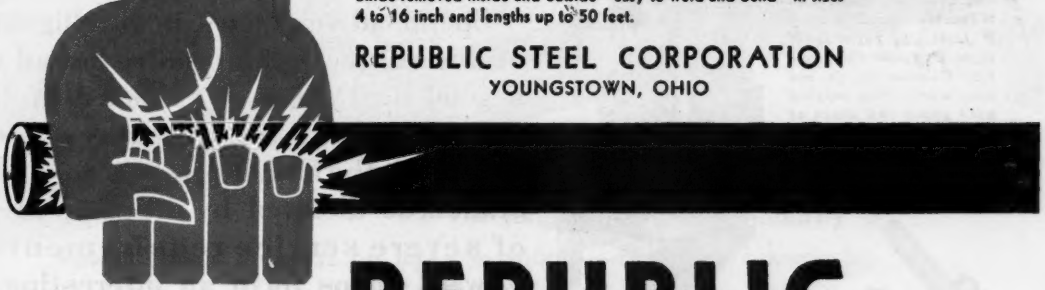
Twelve months ago Republic Electric Weld Pipe was an experiment—a bold experiment. The first mill to produce standard weight pipe by the resistance welding process was in successful operation on small sizes of pipe. The big question was, "Could the larger sizes in active demand be produced by the same method?" Those responsible for the development of the new process said "Yes," and backed their judgment with a ten-million dollar plant.

Thirty to forty miles of finished pipe now produced daily by this huge mill attest the vision of these business pioneers. Into oil, gas and gasoline lines, into factories and into buildings goes the output of this most modern pipe making plant. And as production increases, demand grows even faster, for this unusual pipe offers many advantages:

THE WELD—stronger than the parent metal—guaranteed 100%—with no foreign metal added—and smooth inside and out.

THE PIPE—perfectly round—of uniform wall thickness—all scale and oxide removed inside and outside—easy to weld and bend—in sizes 4 to 16 inch and lengths up to 50 feet.

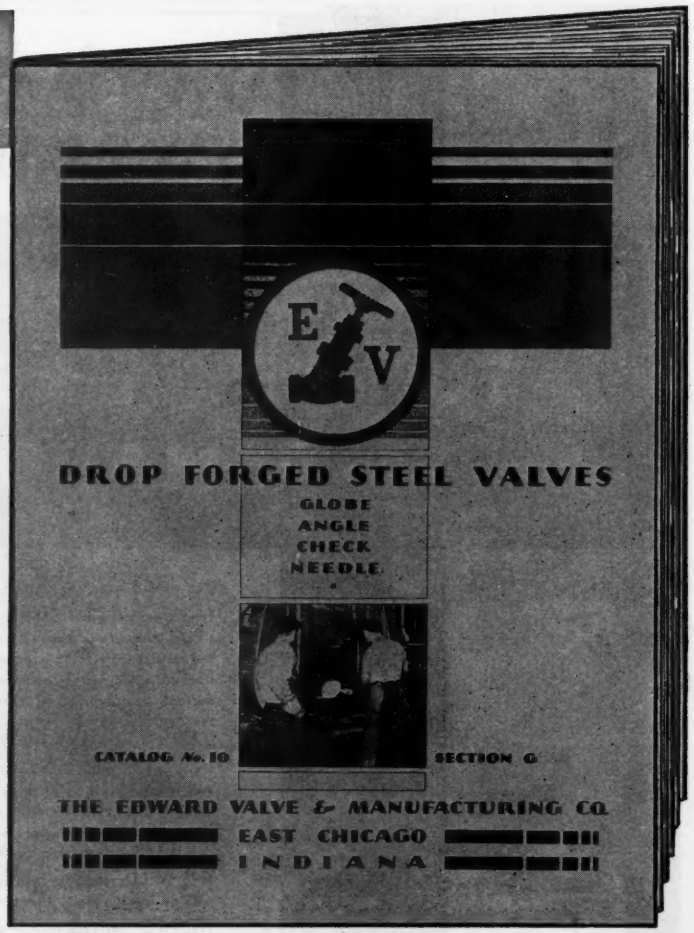
REPUBLIC STEEL CORPORATION
YOUNGSTOWN, OHIO



REPUBLIC ELECTRIC WELD PIPE

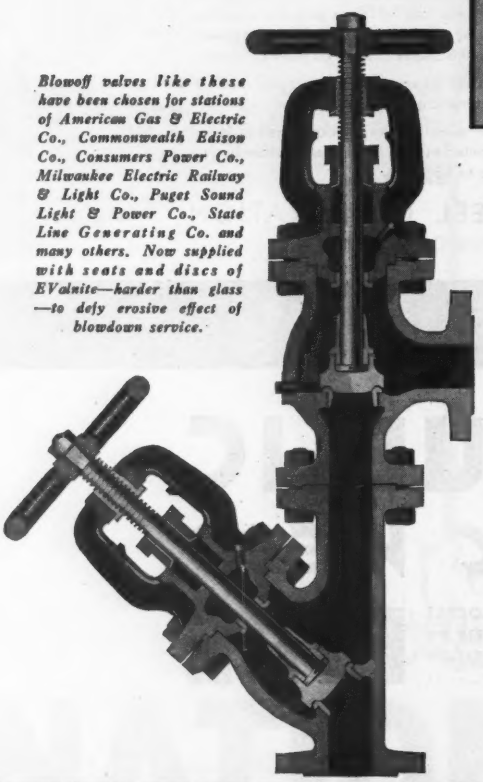
MADE BY A NEW PROCESS CONTROLLED EXCLUSIVELY BY REPUBLIC STEEL CORPORATION YOUNGSTOWN . OHIO .....

Here's the new bulletin, 10G2, on Edward forged steel valves. If you are interested in better small valves, send for this comprehensive manual of globe and angle stops. Check valves, too. Also a new series for hydraulic service to 6000 lbs.



DOING ONE THING WELL

Blowoff valves like these have been chosen for stations of American Gas & Electric Co., Commonwealth Edison Co., Consumers Power Co., Milwaukee Electric Railway & Light Co., Puget Sound Light & Power Co., State Line Generating Co. and many others. Now supplied with seats and discs of EValnite—harder than glass—to defy erosive effect of blowdown service.



Spend all your days in intelligent study of one subject—and you're bound to learn a good deal about it. Edward builds only valves for high temperatures and pressures—at the lowest prices compatible with standards dictated by intimate knowledge of severe service requirements. The Edward shops form an interesting industrial museum of valve history in the making. They are always open to engineers and operators who desire to know *how quality is built into a valve.*

THE EDWARD VALVE & MANUFACTURING CO.
EAST CHICAGO - - - INDIANA

EDWARD VALVES

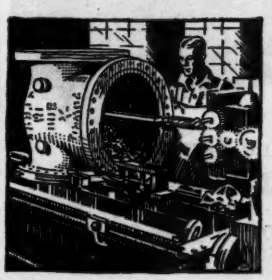
...Try a POWELL★ the better valve

Series No.1 Design
DESIGN - WORKMANSHIP - MATERIALS
Try a POWELL... the better valve
POWELL VALVES
Series No.2 Workmanship
DESIGN - WORKMANSHIP - MATERIALS
+Try a Powell... the better valve!
POWELL VALVES
Series No.3 Materials
DESIGN - WORKMANSHIP - MATERIALS
Try a POWELL the better valve
POWELL VALVES

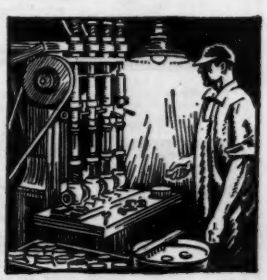
The above advertisements featured the three stages in the processing of Powell Valves.

The long life and dependability of Powell Valves depends on three essentials—Design, Workmanship, Materials. Each factor is of individual importance but collectively they account for the constantly growing popularity of Powell Valves.

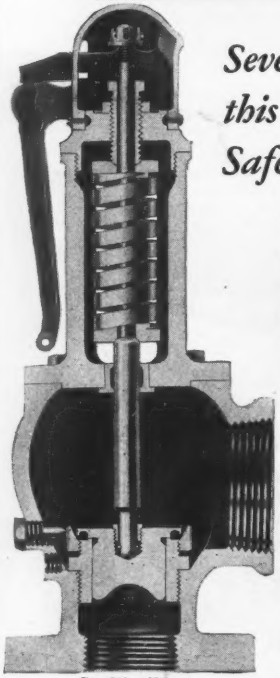
THE WM. POWELL CO., CINCINNATI, OHIO
CHICAGO OFFICE: E. F. SMITH, 55 E. WACKER DRIVE, CHICAGO, ILL.



POWELL VALVES



Lonergan



Pop Safety Valve
Model "WTES" (Steel Body)

Seven advantages of this Lonergan Pop Safety Valve

1 Removable bonnet gives access to interior without breaking pipe connections.

2 Ruggedly proportioned lifting mechanism—simple and trouble-proof.

3 Extra long, fully exposed spring of heat-resisting alloy steel, especially developed for use in Lonergan Pop Safety Valves.

4 Ball joints at top and bottom of spring equalize spring tension.

5 Large, unobstructed opening, preventing back pressure.

6 Very accessible outside adjustment of popping pressure.

7 Entire seat bushing of solid monel composition.

J. E. LONERGAN CO.
217 RACE STREET
PHILADELPHIA, PA.

Williams

The complete line of Williams valves answers the demand for uninterrupted service in the modern power plant. Write for descriptive literature or order a sample from your dealer.

THE D. T. WILLIAMS VALVE COMPANY
CINCINNATI, OHIO

Valves

Fig. 142, flanged, Jenkins Standard Iron Body Globe Valve is recommended for lines 2 inches to 12 inches carrying 150 pounds working steam pressure, 250 pounds water.

JENKINS BROS.
80 White Street.....New York, N. Y.
524 Atlantic Avenue.....Boston, Mass.
133 North Seventh Street.....Philadelphia, Pa.
646 Washington Boulevard.....Chicago, Ill.
1121 No. San Jacinto.....Houston, Texas
JENKINS BROS., Ltd., Montreal, Can.; London, Eng.

Jenkins
VALVES
Since 1864

KENNEDY VALVES

FOR EVERY POWER PLANT SERVICE

Gate, globe, angle and check valves, in bronze, iron-body bronze-mounted, all iron, steel and special material, and for a wide range of pressures. Malleable iron and brass or bronze screwed pipe fittings. Cast iron flanged fittings and flanges. Send for catalog.

New York Chicago Philadelphia San Francisco Seattle

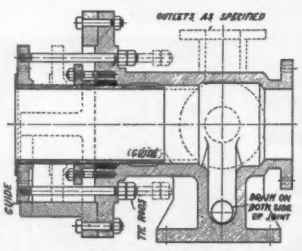
The Kennedy Valve Mfg. Co., Elmira, N. Y.

Cleveland Atlanta El Paso Los Angeles Salt Lake City

GRISCOM-RUSSELL

Evaporators–Feed Water Heaters–Extraction Steam Heaters–Generator Air Coolers–Lubricating Oil Coolers
Steam, Air and Oil Separators–Filters–Strainers–Expansion Joints
Described in bulletins which will be sent on request
THE GRISCOM-RUSSELL COMPANY, 285 Madison Avenue, NEW YORK
Branches in principal cities

SHARON EXPANSION JOINTS

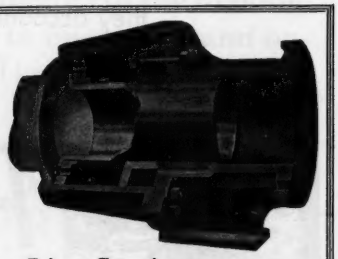


—the Special Sharon Design

includes inside and outside guidance which takes the weight off the packing, insures a longer, leak-proof service. Sizes 1¼ to 36 in. for all pressures of steam or other media. Both High and Low Pressure.

R. W. SHARON COMPANY
3117 Jenkins Arcade Pittsburgh, Pa.

Howard
Guided Expansion Joint



For Pipe Line Service

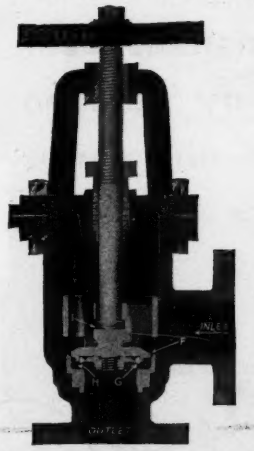
Eliminates trouble from Expansion and Contraction, saves space, labor and repair bills; the construction is mechanically correct.

ALBERGER HEATER CO. 285 Chicago St.
HOWARD IRON WORKS Buffalo, N. Y.

De Laval Worm Gears
Solve the Drive Problem
This 35 ratio gear transmits 5 hp. from a 1200 r.p.m. motor to drive eight 75 ft. glue skids in an oil refinery
DE LAVAL
De Laval Steam Turbine Co., Trenton, N. J.

EVERLASTING-TIGHT

Here is a Rugged



Everlasting's Companion Angle

Reliable ANGLE VALVE which, with Metal-to-Metal contact, without packing, produces a tight seal.

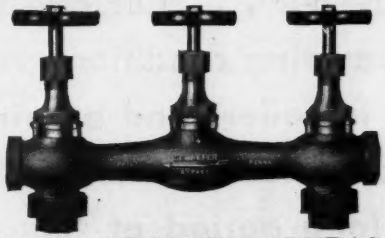
THIS TIGHT SEAL with long life is accomplished by the peculiar constrictor of the Sealing Unit. This Sealing Unit is a loosely fitting Ring, carried by a Guide Head. The Ring, when compressed by the Guide Head against a flat seating surface, produces a tight seal.

THIS PECULIAR CONSTRUCTION of the Sealing Unit permits another individual type of construction in the Seat itself. That Seat is a flat face without any obstruction whatever to the flow of water or solids which the water may carry. The actual contact point is placed outside of the natural flow of the stream, and thus further protects it from any erosion. Just as the valve is being finally closed, this sealing face is cleared of all deposit so that the Ring and the Seat itself make A PERFECT JOINT.

Everlasting Duplex Unit

EVERLASTING VALVE COMPANY
Jersey City, N. J.
In Canada: Everlasting Valve Co., Ltd., Toronto.

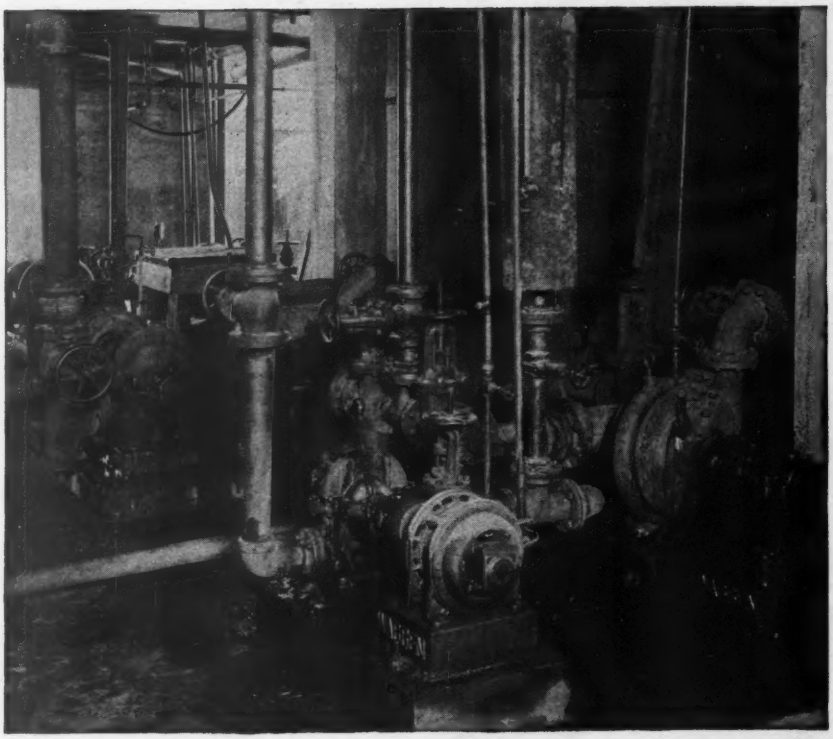
SCHAEFER BYPASS



Use the SCHAEFER BYPASS
when installing
TRAPS, REDUCING VALVES, TEMPERATURE CONTROL VALVES, PUMP GOVERNORS, REGULATORS

1. The Schaefer Bypass positively eliminates twelve points.
2. Saves all labor, valves and fittings formerly required to make twelve connections.
3. By the elimination of possible leaks, the cost of maintenance is much less than required by any other method.
4. The saving in space is an item of importance in many cases, the bypass occupies only one-third the usual space required.
5. From the standpoint of appearance the Schaefer Bypass is a vast improvement over other methods.
6. The compact arrangement effected by the use of the Schaefer Bypass permits considerable saving in covering costs.
7. The uniform arrangement, whereby the center valve is always the bypass, is a feature of value.
8. The renewable seats and discs, in both standard and extra heavy patterns, insure unlimited life of the body.
9. The choice of either the flat seat with composition or metal disc, or the all metal cone disc is an item of importance; the body accommodates either.

H. BELFIELD CO.
435 NORTH BROAD STREET
PHILADELPHIA, PA.
Manufacturing Steam Specialties Since 1836



Battery of six 4" and 5" Warren liquor and clear water pumps in a southern paper mill.

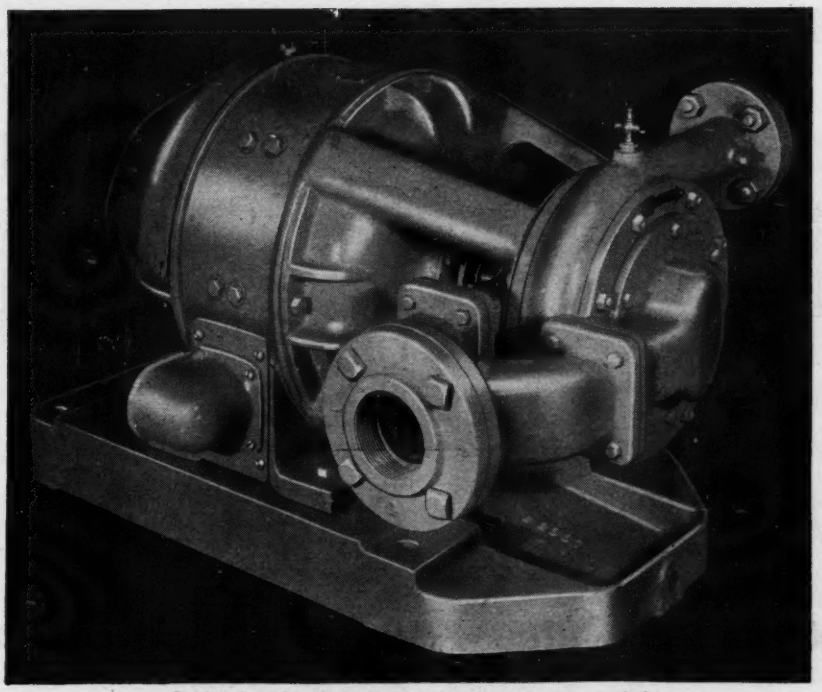
Warren pumps are built to stay on the job 24 hours a day, day in and day out . . . put one to work where service is severe or operating conditions vary widely. Shafts are extra heavy at impellers and bearings to prevent vibration and deflection; liberal clearances maintain original efficiencies over a long period of time and prevent unnecessary wear on case rings; tongue and groove construction of all interior parts eliminates bolts and pins liable to work loose and cause trouble. Bulletins or estimates?

Warren

Steam Pump Company Inc. WARREN **Warren Massachusetts**

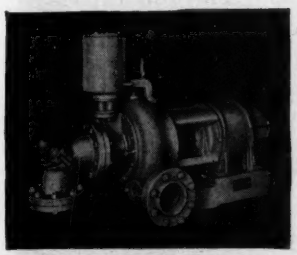
AGENCIES IN ALL PRINCIPAL CITIES

4427

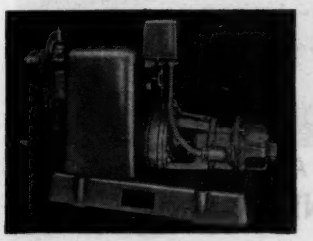


Jennings Centrifugal Pump. Pump and motor mounted on same shaft. Only one stuffing box. No bearings in pump casing.

You can rely on these Pumps *for many power plant services*



Jennings Suction Sump Pump for discharging drains from house turbine, leaks, flushing water, etc. Self-priming; only the suction pipe is submerged in the sump.



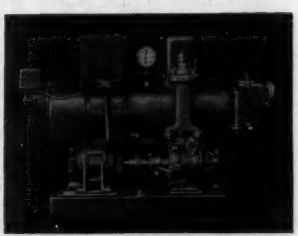
Jennings Condensation Pump for removing condensation from bleeder heaters which are set at a low elevation.

INSTALLING Jennings surge pumps, house service pumps, sump pumps, vacuum heating pumps, and condensation pumps is to be sure of dependable pump performance.

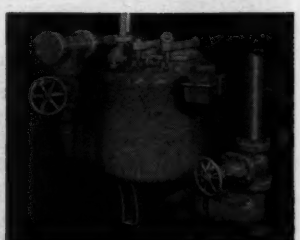
Before leaving the factory, each Jennings Pump is tested and made to demonstrate by actual performance its fitness for the job. By inspection and reinspection during construction, it is made to conform to Jennings standards of quality and workmanship.

For more complete information on Jennings Pumping Equipment, write for bulletins. Nash Engineering Company, 169 Wilson Road, South Norwalk, Conn.

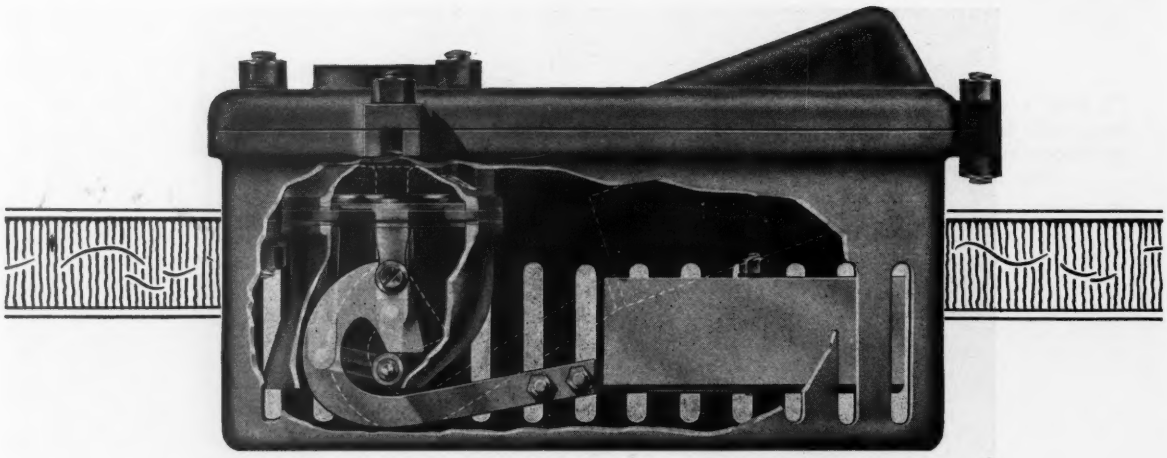
Jennings Pumps



Jennings Vacuum Heating Pump for removing air and condensation from return line vacuum steam heating systems.

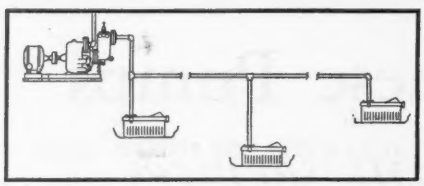


Jennings Pneumatic Sewage Ejector for lifting unscreened sewage from fixtures below street sewer level.



It Isn't A Pump

But It May Save You The Price Of One



The above diagram shows the way in which LaBour Suction Valves are used to make one pump remove the water from several sumps. When each opening is equipped with a LaBour Suction Valve the lines are tightly closed until the water at any one of them reaches operating level. When the float reaches this height it unlocks the valve which is instantly drawn to its full opening by the suction of the pump.

When the water level drops below the valve skirt, air can enter. This immediately rises to the top and passes through the valve opening. The momentary loss of water impact permits the valve to drop closed and the float immediately locks it there when the cam passes above the roller. Instant snap action both in opening and closing eliminates wear and makes for perfect service.

By making it possible for one pump to remove the water efficiently from several sumps, the new LaBour Suction Valves eliminate the necessity for investment in more costly equipment and at the same time reduce maintenance cost. These valves keep the suction lines tightly closed unless there is sufficient water to warrant opening them.

Several sumps at levels varying within twenty feet may thus be connected to a single pump. The full capacity of the pump will always be employed in removing water from the sump or sumps in which the water is standing, and there will be no loss of efficiency due to one or more sumps which may be empty.

The simple rugged construction and the unique principles of LaBour Suction Valves assure long and trouble-free service. They may be used in conjuncton with automatic controls, thus giving entirely automatic service with the same saving in investment and maintenance cost. Full details and information based upon our long experience with problems of this nature may be had for the asking without cost and without obligation.

THE LABOUR COMPANY, INC.

1533 STERLING AVENUE,
ELKHART, INDIANA

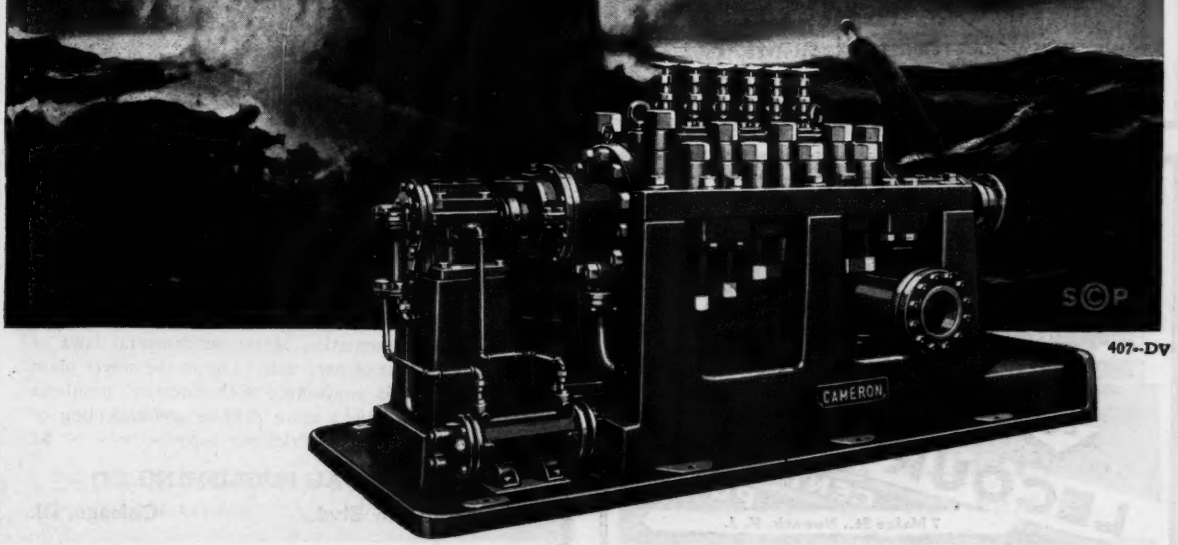
Originators of the Self-Priming Centrifugal Pump

DEPENDABILITY

The dependability for which Cameron Pumps are noted, is due to simplicity, inherent strength, design, high standards of workmanship, and quality of materials used in their manufacture.

INGERSOLL-RAND COMPANY
A. S. Cameron Steam Pump Works
11 BROADWAY · · NEW YORK CITY

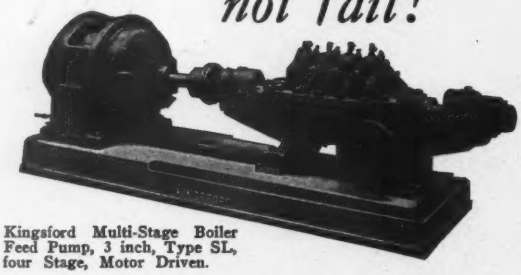
Cameron Pumps



407--DV

KINGSFORD PUMPS

where service must not fail!



Kingsford Multi-Stage Boiler Feed Pump, 3 inch, Type SL, four Stage, Motor Driven.

Modern power plants demand economical, reliable, pumping service and these demands are met in the rugged durability, the scientific design and the economy of trustworthy Kingsford Pumps.

More than thirty years of experience have gone toward perfecting Kingsford Pumps. Get the guaranteed results for your plant that the name "Kingsford" insures.

Performance records are your proof. Write for bulletin No. 56.

Kingsford Foundry & Machine Works

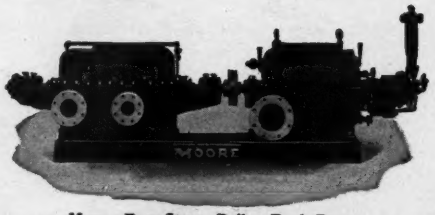
Established 1869

Oswego, New York

MOORE

COMPLETE

BOILER FEED UNITS



Moore Four-Stage Boiler Feed Pump Driven by Moore Seven-Stage Turbine

Undivided responsibility.

Co-operation of turbine and pump engineers to produce best unit.

Built to Steam Turbine standards throughout.

Unit includes pump governor.

Parts made to limit gauges insuring interchangeability.

Descriptive Bulletins on Request

STEAM TURBINES REDUCTION GEARS

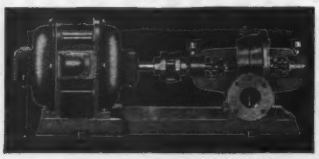
CENTRIFUGAL PUMPS

Offices in All Principal Cities

MOORE STEAM TURBINE CORP.

Wellsville, N. Y.

THE *ORIGINAL* TURBINE TYPE PUMP



WESTCO *TURBINE* PUMPS

HIGH PRESSURES IN SINGLE STAGE

WESTCO-CHIPPEWA PUMP CO.

Factory and General Offices: Davenport, Iowa

Branches: NEW YORK — CHICAGO — SAN FRANCISCO

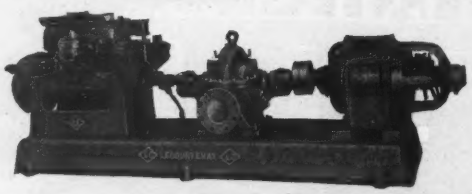
Distributors in Principal Cities

. . . for all Power Plant Services!

—There is no pump needed in your power plant that we cannot supply — an *especially-designed* pump for the individual service: Make-up, condensers, sanitary lines, fire, cooling towers, booster service, etc. Of course a guarantee goes with every Frederick installation! *Write us.*

FREDERICK PUMPS

The Frederick Iron & Steel Co., Frederick, Maryland



LC

LECOURTENAY CENTRIFUGAL PUMPS

7 Maine St., Newark, N. J.

ELECTRICITY

What It Is and How It Acts

This new book by Andrew W. Kramer gives a clear and logical presentation of the fundamental laws of electricity. It is of particular value to the power plant engineer who is confronted with electrical problems and wishes to gain a more definite understanding of underlying principles. Price per copy - - - - $2

TECHNICAL PUBLISHING CO

53 W. Jackson Blvd., Chicago, Ill.

CROLL-REYNOLDS

Engineers and Manufacturers of

Closed Heaters **Surface Condensers**

Evaporators

Heat Exchangers and

Special Heat Exchange Apparatus

"Evactor" Steam Jet Air Pumps and

"Evactor" Steam Jet Thermo Compressors

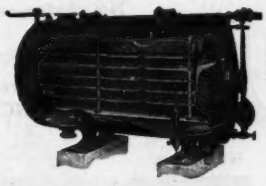
Details on request

Croll-Reynolds Engineering Co., Inc.

17 John Street, New York City

Representatives in Principal Cities

HOPPES Feed Water Heaters *Save Fuel!*

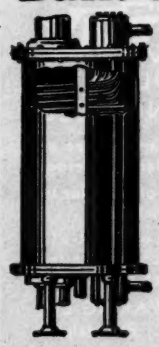


They purify water without the use of chemicals, utilize exhaust steam and operate with little attention —the choice of engineers for more than 40 years.

Catalogue 90 shows Heaters for every purpose, Hoppes Steam Separators, Oil Eliminators, Exhaust Heads, V-Notch Meters, etc.

THE HOPPES MANUFACTURING CO., 70 Larch St., Springfield, O.

Built For Long Service *and* Greatest Efficiency



There is a decided advantage offered to the user of well-designed and built National

Feed Water Heaters

Heat Exchangers

Air Coolers **Oil Coolers**

Backed by 45 years of manufacturing high-grade equipment. Each job individually engineered. Write for descriptive bulletins.

The National Pipe Bending Co.

Est. 1883

160 River St., New Haven, Conn.

Boston New York Philadelphia

CONTROLLERS FOR INDUSTRY

Automatic Controllers for Combustion, Temperature, Frequency, Acidity, Alkalinity, Humidity, Etc. Thousands in use. Ask for Bulletins.

LEEDS & NORTHRUP COMPANY

4901 STENTON AVENUE :: PHILADELPHIA, PA.

a super machine in a world of wonderful machines

BURKE ARC Welders

◆ Every requirement for the best in effective and satisfactory Electric Arc Welding is fulfilled in BURKE Welders. They are, without a doubt, the most advanced welders that engineering science and practical experience have been able to produce.

Their design and construction give to them welding characteristics which enable the operator to hold a stable short arc with minimum physical strain.

Producing a short arc of maximum stability and proper intensity the heat is concentrated in the smallest possible area, thus an ideal welding condition is maintained at all times.

Compact in design — sturdy in construction — welded steel frames — splash proof — protected from external injury—impossible for pieces of metal and (other foreign matter) to fall into working parts, and being semi-enclosed they are protected from the elements.

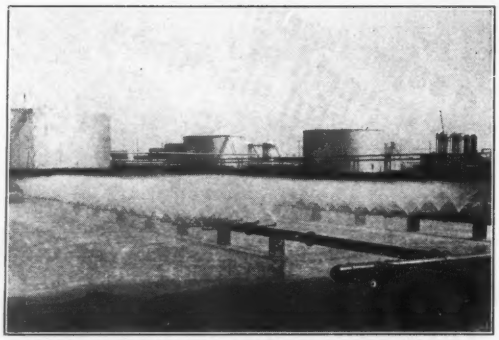
These features with the following 5 BURKE Strong Points: (1) CONTROL LEVER, easily accessible, makes possible instant adjustment to the most efficient welding current; (2) GRADUATION OF CURRENT—an infinite number of steps in current control are made possible by one control lever; (3) STRIKING THE ARC is always the same regardless of the current setting; (4) SAME CHARACTERISTICS OF WELDING ARC throughout welding range; (5) SELF EXCITED GENERATOR—built into the machine; make BURKE Arc Welders a superior machine in a world of wonderful machines.

BURKE

ELECTRIC COMPANY

Main Office and Works: ERIE, PA.

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES



The illustration above shows a Marley Spray Pond in use by one of America's largest companies

Maximum Cooling Efficiency with Marley Cooling Equipment . . .

MARLEY water cooling systems provide the three essentials of water cooling efficiency — pumping economy, thorough water break-up and entire freedom from clogging.

This balanced performance accounts for Marley economy and assures maximum cooling efficiency.

Before you install new systems or enlarge or improve old ones—it will pay you to investigate the Marley line.

SPRAY NOZZLES—SPRAY PONDS—SPRAY TOWERS
DECK TOWERS—LOUVRE FENCES AND
ALL ACCESSORIES

Marley Patented Spray Nozzles

MARLEY non-clog spray nozzles provide a fine, uniform spray at low pressures because of their simple design and large free passages. These nozzles are a part of all Marley installations and can also be used to greatly improve the efficiency of other cooling systems.

Full Information Upon Request

THE MARLEY CO.

1737 Walnut St., Kansas City, Mo.

Representatives in Principal Cities

Large Marley Deck Type Tower of 7000 gallons capacity

BINKS

SPRAY COOLING SYSTEMS

Cost Less —

to Install
to Operate
to Maintain

For full information on spray cooling systems write for Bulletin 4-E. No charge—no obligation.

BINKS MANUFACTURING CO.
3130 Carroll Avenue
CHICAGO

One of our 2500 installations.

YARWAY

INVOLUTE
SPRAY NOZZLE

No internal parts, vanes or deflecting plates to clog.

Minimum loss of head due to less internal friction.

Write for Booklet N-613 describing the comprehensive range of sizes and types.

YARNALL-WARING CO.
Mermaid Ave., Philadelphia

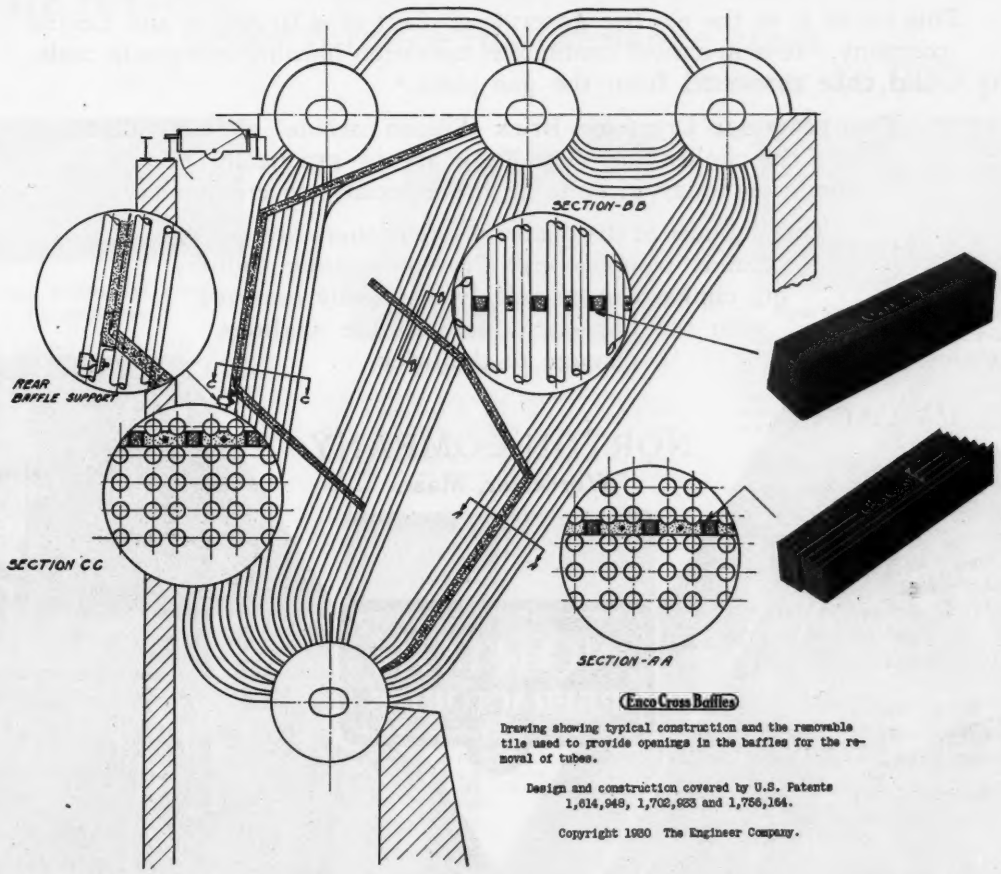
C. H. WHEELER of PHILADELPHIA

Surface Condensers, Jet Condensers, Barometric Condensers, Leach Fracto Control Condensers, Oil Vapor Condensers, Heat Exchangers, Ejector type Air Pumps for vacua up to 29.95 inches, Natural and Forced Draft Cooling Towers.

C. H. WHEELER MANUFACTURING COMPANY
19th Street, Lehigh & Sedgley Avenues, Philadelphia, Pa.

Enco Cross Baffles

For water tube boilers



Enco Cross Baffles

Drawing showing typical construction and the removable tile used to provide openings in the baffles for the removal of tubes.

Design and construction covered by U.S. Patents 1,614,948, 1,702,983 and 1,756,164.

Copyright 1930 The Engineer Company.

Enco Cross Baffles Construction
is designed for easy tube renewals

To provide for tube renewals in vertical water tube boilers, in the usual manner, and without breaking up or shattering the baffles, The Engineer Company has developed a patented reinforced construction for Enco Cross Baffles.

Either corrugated or tapered tile are used in the wide tube alleys and steel reinforcing rods are bedded in the refractory between the narrow tube alleys.

Breaking out the tile and chipping away a slight amount of plastic makes an opening of ample clearance for taking out a defective tube and replacing it with a new one. The broken out slot is then refilled with new tile, bedded in new plastic and the baffle is quickly rebuilt and ready for service.

Write for the Enco Baffle Book

The Engineer Company 17 Battery Place New York

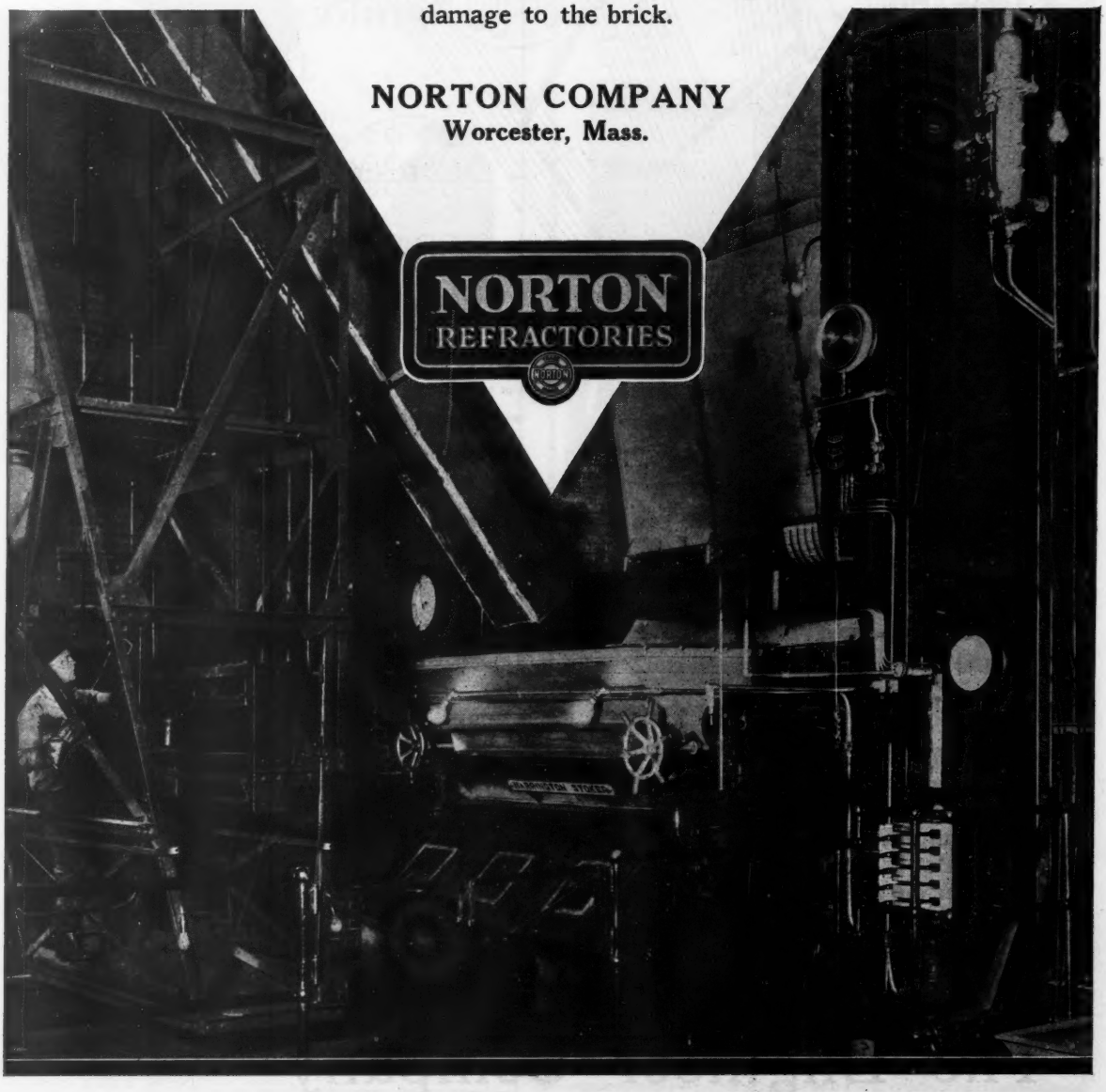
There Are No Slag and Clinker Troubles Here— *in spite of Low Grade Fuels*

This boiler is in the electric generating plant of a large gas and electric company. It is in almost continuous operation burning low grade coals and coke recovered from the gas plant.

Two years ago Crystolon Brick (Silicon carbide) were installed along the clinker line. The brick are in practically perfect condition today in spite of the especially severe service.

The engineer of the plant says that there are no slag or clinker troubles with Crystolon Brick. Adhering clinker can be quickly and easily removed with the bar — and without the slightest damage to the brick.

R-396



NORTON COMPANY
Worcester, Mass.

Some of the STEEL MIXTURE REG. U.S. PAT. OFF. Products

that are reducing boiler furnace maintenance costs in over 16,000 plants

Boiler-Door Arches and Fire-Box Lining Blocks

Furnished in complete sets of exactly the right shape to fit the furnace, and tongue-and-grooved for perfect alignment. The large blocks with few joints save time, labor and money, resist cracking, checking and spalling, and last twice as long as ordinary brick settings.

Fire Brick and Plain Tile

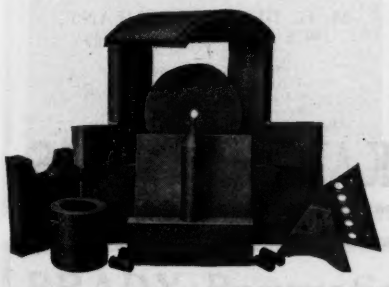
Highest quality of fire clay refractory furnished in all standard shapes and sizes.

Repair Daub

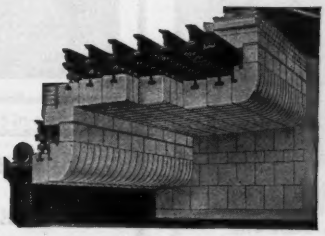
Superior for temporary patching of surfaces and plugging of holes in exposed fire wall face. Quickly mixed and applied, or supplied already mixed.

Carbex

Super-refractory Bricks and Blocks

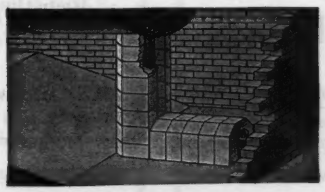


Essential where extreme furnace heat prevails from high boiler pressure, forcing, oil or gas firing or with fuel carrying excessive clinker formation. Extremely hard, dense, and resistant to softening, cracking, checking, and surface disintegration. Clinkers do not fuse with the surface to form slag, and cleaning tools will not break off chips. Obtainable in any desired contour.



Flat Suspended Furnace Arch

Independently suspended standard interchangeable blocks which are separately removable from underneath without disturbing I-beams or brickwork. Adapted to all types of boilers, and as the suspension is out of the hot gases, the life of all parts is long and the maintenance low.



Blow-off Pipe Protectors

Shield the pipe from the hot gases and avoid the frequent annoyance and renewal expense of rebuilding the fire brick piers ordinarily used for the purpose. Quickly installed, taken down and reassembled.

OUR very complete line of Steel Mixture and Carbex refractories enables us to furnish the most desirable refractory materials and all plain fire brick and cement needed at every location in any power boiler and in most types of industrial furnaces. An experienced engineering staff is prepared to study special furnace conditions and make authoritative recommendations.

The large stock of all refractory shapes and sizes constantly on hand enables us to make quick shipments, especially in emergency cases.

Back Combustion Chamber Arch

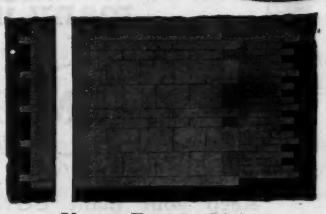
Protects the flue sheet of h.r.t. boilers down to and below the water line. Suitable for boilers of any size, easily assembled, and serviceable for the life of the boiler. The blocks on the under side are curved to deflect the gases toward the flues and the whole construction is gas-tight.

Baffle Tiles

Suitable sizes and shapes for all makes of water tube boilers carried in stock or made to order.

Fire Cement

A scientifically correct mixture for grouting, plugging small holes and patching. Will not melt or injure bricks or blocks, air-sets without heat, and bonds joints perfectly.



Veneer Furnace Lining

Forms the inner or fire side of the furnace lining, the outside half of the wall thickness being laid with standard fire brick. Reduces the cost and time of repairs as the fire bricks are protected from the furnace heat and need not be replaced when repairs are needed.

Write for bulletin

fully explaining the special advantages of Carbex and Steel Mixture Refractories.

McLEOD & HENRY CO.

Specialists in Furnace Refractories for More Than a Hundred Years

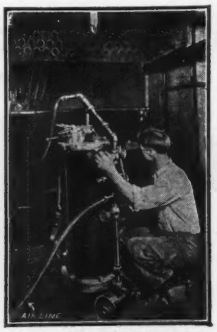
29 Monroe St., Troy, New York

Branches: New York, Boston, Cleveland, Detroit, Buffalo

A Chief Engineer Says—

"We saved $859.50 by building new baffles with HYTEMPITE and the Quigley Refractory Gun."

This gun handles premixed refractories or other materials. It shoots the plastic mixture with high velocity at any place in wall or arch. The mixture will stick to a hot or cold wall, owing to force of application, in cases where troweled or rammed-in applications might fail to hold. You can



Repairing Baffle with Quigley Refractory Gun

Fill Cracks or Holes
Restore a Burned-out Wall
Fill Gaps in Walls or Arches
Re-surface Old Walls
Repair Leaky Baffles
Build New Baffles
Surface New Walls

And in many cases you can make repairs while furnaces are hot.

A whole battery of furnaces can be repaired in the time formerly required to repair one.

Used by many large Industrial Plants and Public Utilities. Details are described in *Booklet PG-138.*

QUIGLEY COMPANY INC.
INDUSTRIAL SPECIALTIES
56 West 45th Street, New York
Distributors with Stock and Service in every Industrial Center

There IS a Santa Claus!

You, for instance, can be Santa Claus to your boiler. You can MODERNIZE it and make it *more efficient* by having BECO-Turner Boiler Baffle Walls installed in it. You can't give your boiler a better Christmas present. Save at least 3% of the fuel. BECO-Turner Baffle Walls, remember, are the *only* truly flexible baffles. Never any cracking, breaking, or leaking. They assure maximum efficiency during the entire life of the boiler. Send a sketch of your boiler and we will gladly quote. No obligation at all.

Boiler Engineering Co.,
24 Commerce St.
Newark New Jersey
Sold by all Plibrico Agents in the U. S. and Canada.

High Temperature Cements

FIREBOND THERMOLITH

REFRACTORIES

Fire Clay **Silica**
High-Alumina **Chrome** **Magnesite**

Acid-Proof Brick

HARBISON-WALKER REFRACTORIES CO.
World's Largest Producer of Refractories **PITTSBURGH, PA.**

A Review of the Year shows many installations

with THE CEMENT-GUN TRADE MARK

Keep your plant CONTINUALLY in good shape with a "Cement-Gun" on hand ready to line furnace walls when the boilers are down, and for many other uses.

Call on our Contract Department for lining stacks, bunkers, breechings, repairing buildings, etc.

Cement-Gun Co., Inc., Allentown, Penna.

Cement-Gun Co., Inc., Allentown, Penna.
Send catalogue showing leading plants that use the "Cement-Gun" and its many other uses inside and outside the plant.

Name .....

Address .....

City .....

State .....

There are now more than 14,000 installations of DETRICK ARCHES and DETRICK SECTIONAL SUPPORTED WALLS in satisfactory service.

The experience gained in solving this large number of furnace problems is offered to you for the solution of your own.

M. H. DETRICK COMPANY
140 S. Dearborn St., Chicago
—⊙—
New York: 50 Church St.
Pittsburgh: Empire Bldg.
Detroit: Murphy Bldg.
San Francisco: Russ Bldg.
Sales Engineers in principal cities

DETRICK ARCHES & WALLS

Storage Batteries

By Morton Arendt.

Complete treatment of principles of action of batteries, details of construction and of care, operation and maintenance. Written specially for the man in charge of the plant to insure satisfactory service. 285 pp. Fully illustrated. Price $4.50.

POWER PLANT ENGINEERING
53 W. Jackson Blvd., Chicago, Ill.

Repairs—Consulting—Material—Tools and an Efficient Organization

We specialize in HEAT EXCHANGE repairs—CONDENSERS—HEATERS—STILLS, etc.

No Job Too Large—Or Too Small.

We tubed, rolled and packed the World's Largest Existing Condenser—New York Edison Co.
The Smallest Diesel Inter-cooler—7 tubes—2500 pounds test pressure.

We have a trained organization prepared to work 24 hours per day—7 days per week.

We Work Anywhere.

Week End and Holiday Work Our Specialty.

SPEED—QUALITY—ECONOMY—A Special Tool has been designed to meet each problem.

Condensers packed with METALLIC, CORSET LACE, FIBRE rolled One or Both Ends.

If you have CONDENSER PROBLEMS let us help you solve them.

DEZINCIFICATION—ELECTROLYTIC ACTION RETARDED: Device to remove air from circulating water—an occasional tube going bad means trouble, but not necessarily retubing—OUR DEVICE LOCATES BAD TUBES IN ADVANCE OF FAILURE.

PERMIT US TO HELP WITH YOUR PROBLEMS ADDITIONAL INFORMATION OR A REPRESENTATIVE WILL CALL ON REQUEST. ESTIMATES PROMPTLY AND GLADLY FURNISHED.

Condenser Service & Engineering Co., Inc.
310—12th Street, Hoboken, N. J.

Low-Cost Coal Storage

Sauerman Drag Scraper Systems for storing and reclaiming coal satisfy the power plant engineer's demands as to (1) Low cost, (2) Large capacity, (3) Easy operation and maintenance.

Suited to plants of every size.

Write for 56-p. Catalog

SAUERMAN BROS., Inc.
486 S. Clinton St.
Chicago

BRADY Pneumatic System

Unloads coal and all loose industrial materials, at low cost, dependably and dustlessly.

Also manufacturers of

All Kinds of Coal and Ash Handling Equipment

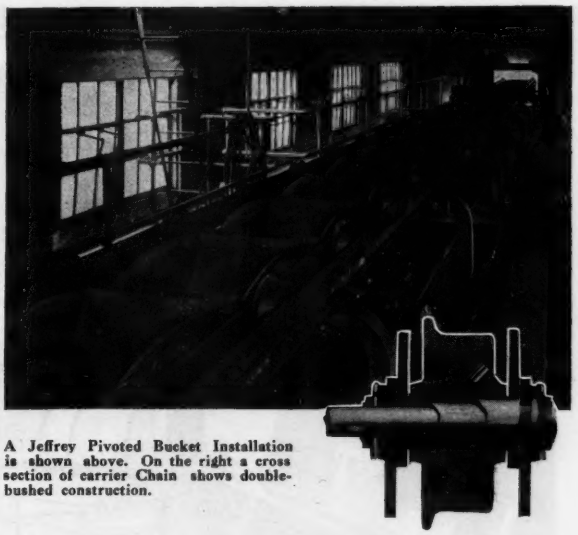
Coal Storage Equipment **Ash Sluicing Systems**

Ash Bins, Gates and Doors

Bucket Elevators **Skip Hoists**

It will pay you to put your problems up to the wide experience of our engineering department. No obligation. Write.

The Brady Conveyors Corporation
20 W. Jackson Blvd., Chicago, Ill.



A Jeffrey Pivoted Bucket Installation is shown above. On the right a cross section of carrier Chain shows double-bushed construction.

Where Breakdowns Mean More than a Repair Bill

They Use the Jeffrey Pivoted Bucket

Those plants where interference with the flow of coal to boilers is too disastrous in consequence to be even contemplated are very likely to have Jeffrey Pivoted Bucket Carriers.

If breakdown brings in its train the costly shutdown of other departments—the failure to give service when service is demanded—then you too need the Jeffrey Pivoted Bucket Carrier.

The Jeffrey Pivoted Bucket Carriers are as near breakdown proof as they can be made. Every part is double guarded against failure.

Unique chain construction puts all wear on double glass hard bushings. Tough malleable buckets, rollers and tripping cams of tough, hard chilled iron—strength everywhere.

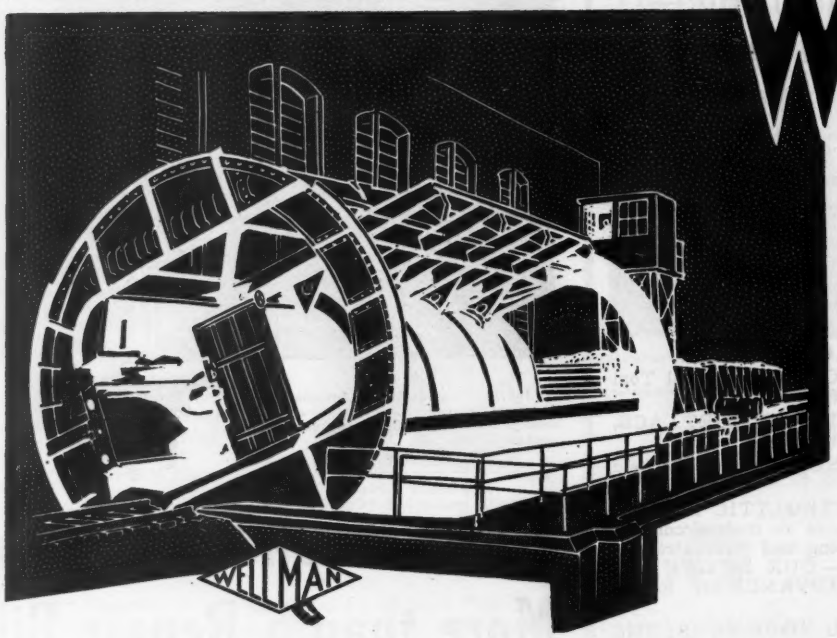
The Pivoted Bucket Carrier will elevate your coal, distribute it to bunkers or storage, reclaim from storage, and carry out the ashes—all in one unit. Write for Bulletin No. 210-G which describes the dean of conveyors.

The Jeffrey Manufacturing Company
905-99 North Fourth St., Columbus, Ohio

New York	Utica	Detroit	Denver
Buffalo	Boston	Chicago	Houston
Rochester, N. Y.	Scranton, Pa.	Charleston, W. Va.	Salt Lake City
Philadelphia	Cincinnati	Milwaukee	Birmingham
Pittsburgh	Cleveland	St. Louis	

Jeffrey Manufacturing Co., Ltd., of Canada.
Head Office and Works: Montreal—Branch Office: Toronto

JEFFREY
MATERIAL HANDLING EQUIPMENT



WELLMAN

Revolving CAR DUMPERS

Where coal is handled in quantity, the Wellman Revolving Dumper is the first step toward economy.

It dumps coal cars at surprisingly low cost and permits the use of modern weighing and conveying equipment.

It short circuits a lot of expense.

THE WELLMAN ENGINEERING CO.
ENGINEERS CONSTRUCTORS MANUFACTURERS
CLEVELAND, OHIO

New York at 30 Church St., Birmingham at 1101 American Trust Bldg., Chicago at Room 523-549 W. Washington Blvd. "Canadian Wellman-Seaver-Morgan Co., Limited," 307 Reford Bldg., Toronto—821 Castle Bldg., Montreal. Mexico City at Edificio Oliver, 16 De Septiembre No. 5.

Formerly THE WELLMAN-SEAVER-MORGAN CO.

THE FAIRFIELD WAY

FOR FAST, ECONOMICAL HANDLING OF COAL

The Fairfield handling equipment at the Eaton Axle & Spring Company's plant, Cleveland, Ohio, consists of a Type "A" Overtrack Feeder beneath the rails, a Standard 35 ft. portable drag conveyor, and a 60 ft. horizontal stationary drag conveyor.

The stationary conveyor extends over coal bunkers and is fitted with discharge gates to uniformly fill a 60 ft. bunker. This equipment has a capacity of 60 tons of mine run coal per hour. *Feeder and Portable conveyor can be used to store coal on the ground outside if necessary,* and reclaimed by the same equipment.

Write for estimates and suggestions for *your* needs.

THE FAIRFIELD ENGINEERING CO.
MARION, OHIO

FAIRFIELD

ELEVATING *and* CONVEYING MACHINERY

COAL AND ASH HANDLING EQUIPMENT

ENGINEERED *FOR GREATEST ECONOMY*

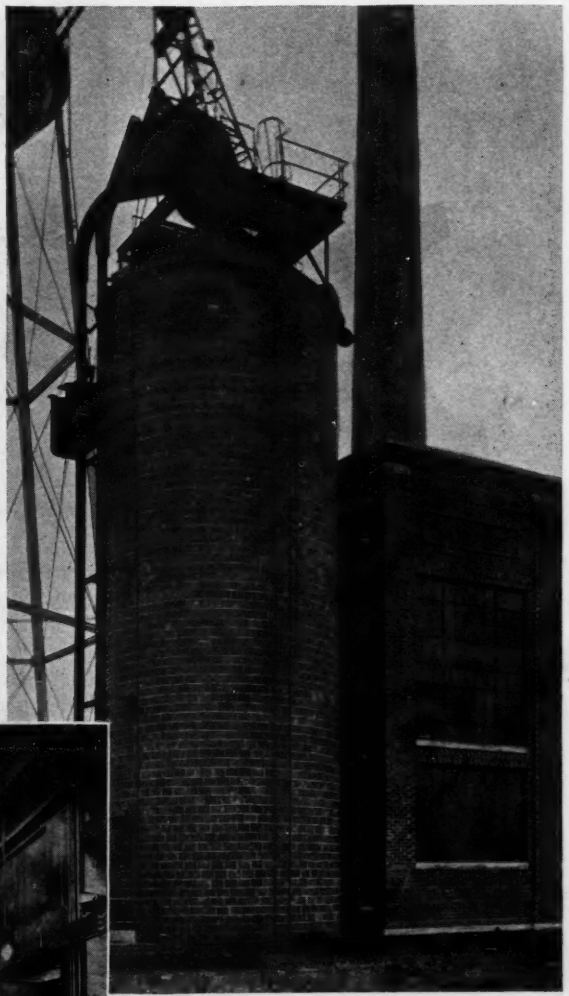
Providing large storage space on limited ground area

Restriction in the space available for reserve storage was a determining factor in the design of the coal handling equipment for the Timken Roller Bearing Company in Canton, Ohio. An installation, engineered by Bartlett & Snow, overcomes this handicap by providing space for both reserve and live storage in a single silo.

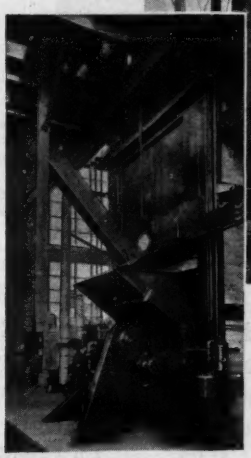
Coal, dumped into a track hopper, moves through a crusher to an automatic skip hoist which elevates it to a steel hopper, built inside the upper part of the silo. This hopper provides live storage space for a carload of coal. Excess coal overflows the hopper into the silo where there is reserve capacity for six additional carloads. A chute from the reserve storage space feeds coal back into the skip hoist which returns it to live storage.

Coal from the live storage hopper is fed by a chute into a weigh larry in the boiler room, and distributed to the stoker hoppers.

Bartlett & Snow engineers bring no preconceived solutions to their consideration of your coal and ash handling problems. Each installation is engineered to provide efficient and economical operation in meeting the requirements of existing conditions. Bartlett & Snow's years of experience in designing coal and ash handling equipment can help you in the solution of your problems. Write, without obligation, for information.



This silo provides both live storage and reserve storage at the Timken Roller Bearing Company.



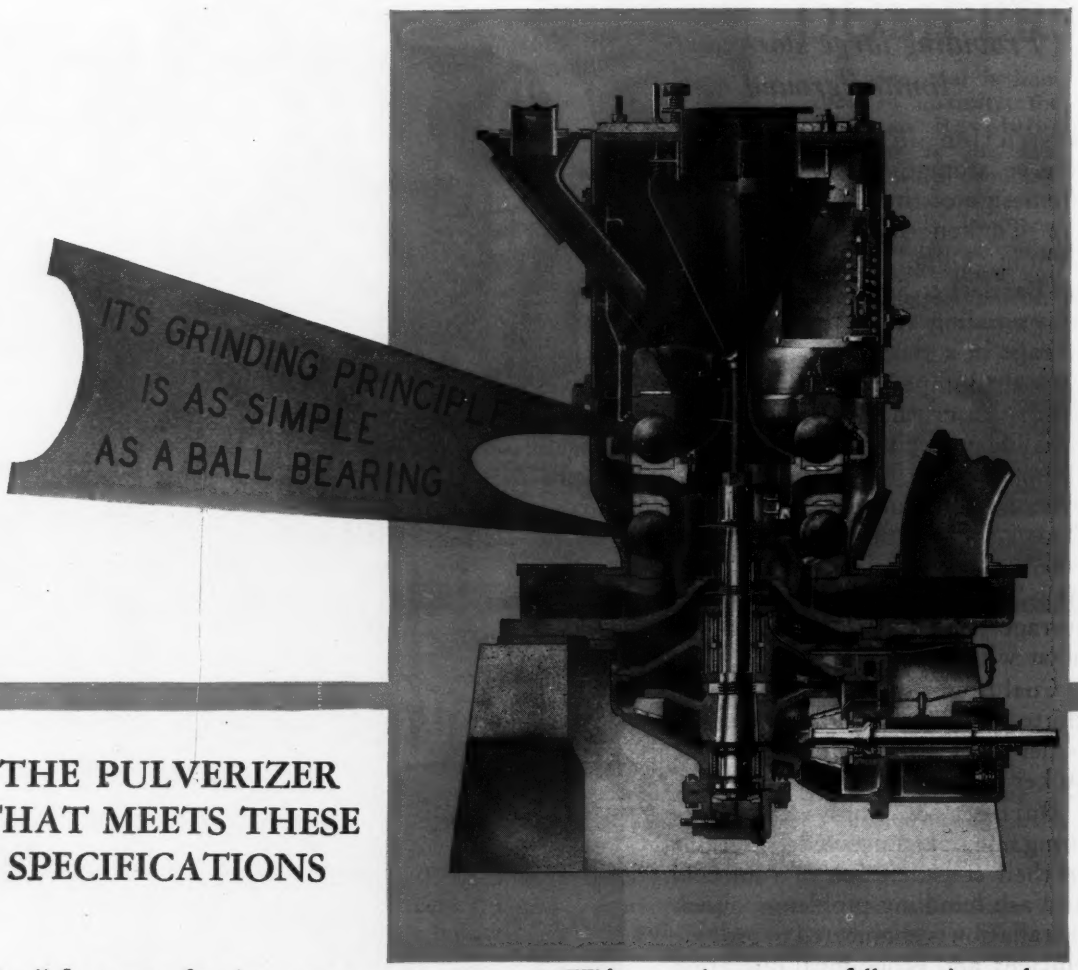
Coal from the live storage hopper is fed into the weigh larry and distributed to the stoker hoppers.

THE C. O. BARTLETT & SNOW COMPANY · 6238 Harvard Avenue · Cleveland, Ohio

FOR THE DOMINION OF CANADA
PEACOCK BROTHERS, LTD., MONTREAL

BARTLETT-SNOW

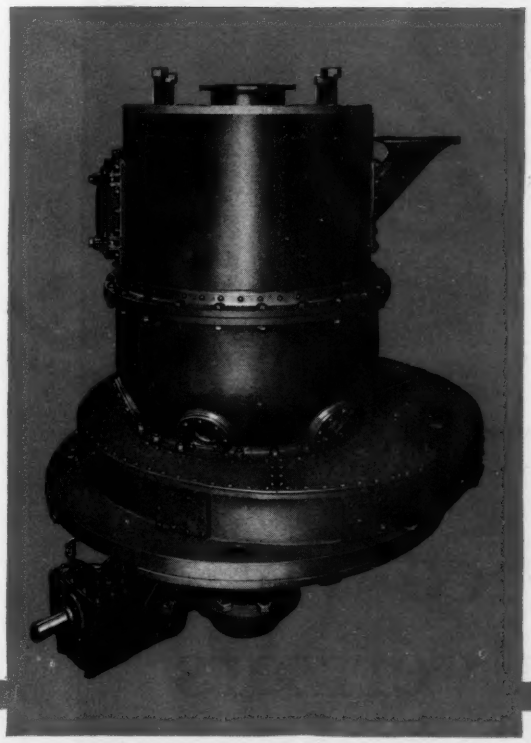
NEWLY DESIGNED MILL SETS NEW STANDARD OF



THE PULVERIZER THAT MEETS THESE SPECIFICATIONS

1. Small floor space for given output.
2. Constant-speed motor drive.
3. Low power consumption.
4. Power varying with rate of coal feed.
5. No lubrication within grinding zone.
6. Grinding zone sealed from parts requiring lubrication.
7. Smooth running and quiet.
8. Grinding pressure independently applied and not dependent on speed of mill.
9. Wide operating range — full capacity to the minimum permitted by the burners.
10. Respond quickly, but not too quickly, to change in rate of coal feed.
11. No metal-to-metal abrasion of grinding parts.
12. Fineness not affected by wear of grinding parts.
13. Fineness always under control.
14. Pulverize coal of any hardness or grindability.
15. Maintenance exceptionally low.

PULVERIZER PERFORMANCE



The new Fuller Lehigh Type B Pulverizer. An air-separation ball mill having a highly efficient method of grinding. The grinding parts consist essentially of two rows of large diameter balls, one rotating and two stationary rings. The rows of balls—one row mounted above the other—are separated and propelled by the rotating ring which floats on the main driving shaft. Grinding pressure between the balls and rings is applied and kept uniform by externally controlled steel springs.

THE new Fuller Lehigh Type B Pulverizer in meeting these specifications has set new standards of pulverizer performance. All the desirable features of the well-known Lehigh Mill are retained in the design of the new mill—including the spherical-ball and grinding-ring principle of pulverizing in which fineness is not affected by wear of grinding parts, and the absence from the grinding zone of parts that require lubrication.

Since pressure between the balls and the grinding rings is an important factor in obtaining fineness and capacity, the new mill is so designed that this pressure—any amount desired—is obtained independently of the mill speed. And, this outstanding feature, combined with the use of two full rows of balls grinding at low speed, has resulted in a quiet, smooth-running mill which gives high capacity and fineness.

In a Type B Pulverizer there is no metal-to-metal abrasion of the grinding parts, therefore, wearing of these parts is the result of coal abrasion. The balls wear spherically and uniformly. As a result the mill has exceptionally low power consumption and maintenance. The power consumed varies with the coal feed.

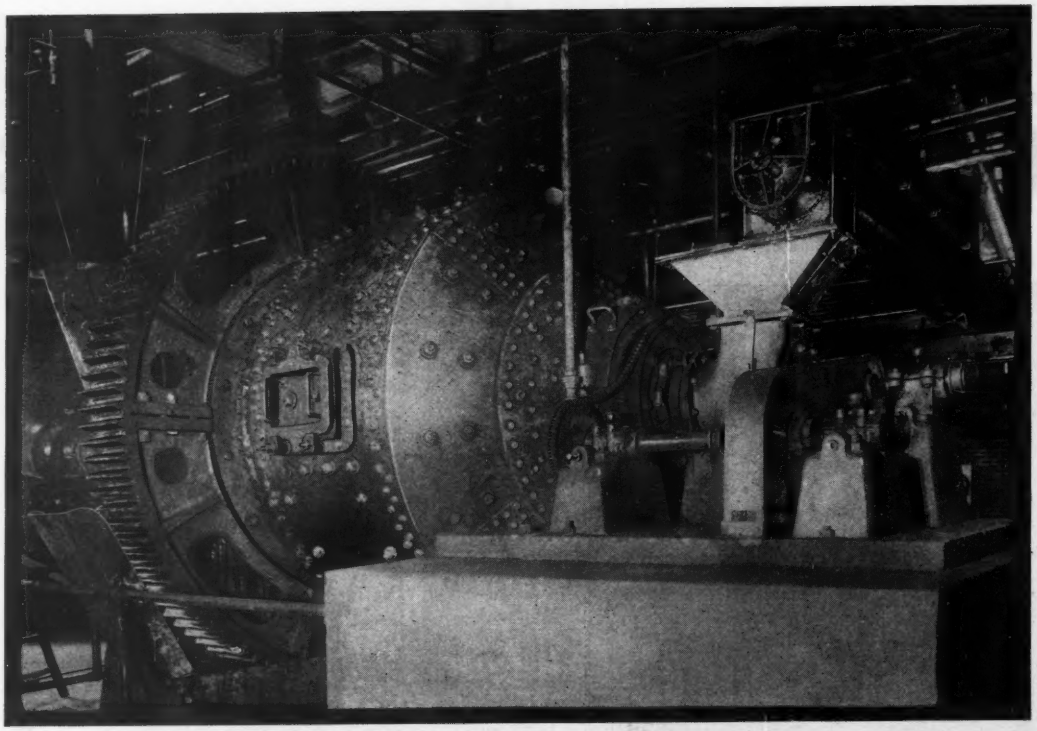
Type B Pulverizers are particularly well suited to serve both large and small direct-fired boilers including those units which have rapidly fluctuating industrial loads. The mill is equally well adapted to the requirements of the storage system of pulverized-coal firing.

May we send you a copy of Bulletin 5-80 which describes this mill?

FULLER LEHIGH COMPANY
A Babcock & Wilcox Organization
FULLERTON, PENNA.

FULLER LEHIGH

PULVERIZED-COAL EQUIPMENT ~ WATER-COOLED FURNACE WALLS 124-T



Hardinge ball mill pulverizer 6 ft. in diameter. This mill has the capacity to pulverize seven tons of fuel per hour.

Heavy Service with Hardinge Pulverizers

The service records of the two Hardinge pulverizers illustrated will be of interest to engineers studying the preparation of difficult fuels.

The satisfactory performance of the smaller mill (shown above), when pulverizing anthracite, led to the installation of the large mill (illustrated on the opposite page). The maintenance costs of the large mill over the period of a year amounted to less than two cents per ton of fuel pulverized, when handling more than 75 percent anthracite coal.

The operation of Hardinge ball mills is simple. The operator has positive and immediate control

AERO UNIT COAL PULVERIZERS
AIR HEATERS CENTRIFUGAL PUMPS
CONDENSERS COOLING TOWERS
ECONOMIZERS EVAPORATORS
EXPANSION JOINTS FEED WATER HEATERS

FOSTER

over the fineness of product and the quantity of coal delivered. Uniformity of pulverization is assured by an air classifier within the mill. This is so designed that the coarse particles are forced back toward the feed end, while the fine particles are carried out of the mill.

The construction of the mill provides a truss-like structure which gives the mill maximum strength and rigidity. The same structural feature also provides good balance and is economical in floor space.

Hardinge ball mills may be used for both the unit and storage systems for firing pulverized fuel.

FOSTER WHEELER CORPORATION
165 Broadway, New York, N. Y.

Foreign Associates—
Foster Wheeler Limited: London, England.
Societe Anonyme Foster Wheeler: Paris, France.
Foster Wheeler Limited: Toronto-Montreal, Canada.

Branches in Principal Cities

10 ft. Hardinge ball mill having the capacity to handle 25 tons of coal per hour. The maintenance cost of the mill during an entire year's operation was less than two cents per ton of fuel pulverized.

WHEELER

FRACTIONATING TOWERS HEAT EXCHANGERS
STEAM JET AIR PUMPS SUPERHEATERS
TUBE STILLS VACUUM PUMPS
WATER COOLED FURNACE SURFACES
BRASS AND COPPER TUBING AND PIPE

Patented Shredder Ring that splits the coal.

1930 ***has shown the economy of crushing coal to correct size*—and the advantges of the New "S" Type Series of AMERICAN Ring Crushers**

Tramp metal cannot injure American Ring Crushers.

The breaker, grinding plate, grate bars and rings are of manganese steel — maximum life and low maintenance.

Simple design and sturdy construction to withstand the most severe service without failure or repairs.

Used by

Acme Steel Co.
Buck Steam Station
Bayside Plant
Twin Branch
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Paul A. Sorg Paper Co.
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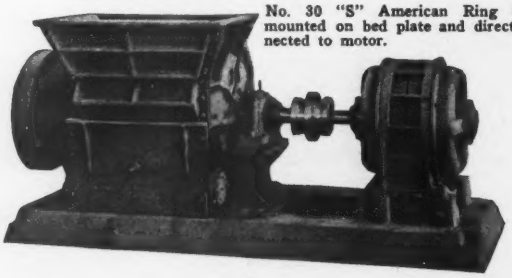
University of Illinois
East River Station
Philo Station
N. Y. Steam Corp.
Cahokia Station
Cement-Gun Co.
Sears-Roebuck Co.
Columbia Station
—and many other leading industrial plants and central stations.

In one operation American Ring Crushers reduce R.O.M. or lump coal to sizes required for pulverizers or stokers. Centrifugal force is used at right angles to the horizontal shaft. Coal enters the crusher from the top, falls on and is struck by the rings in suspension. The rings shatter and distribute coal before it reaches the breaker and grinding plates.

The New "S" Type American Ring Crushers have set new records for low cost, dependable service. Heavy construction, special steels, simplicity of design, anti-friction bearings in dust-proof housing are a few of its distinguishing features.

Write for the details of the achievements of the New "S" Type Series Coal Crusher.

Reduce your coal costs in 1931



No. 30 "S" American Ring Crusher mounted on bed plate and directly connected to motor.

AMERICAN PULVERIZER CO.
1249 Macklind Avenue
St. Louis, Mo.

Originators of the Rolling Ring Crusher Principle

BETHLEHEM PULVERIZERS *for* POWER PLANTS

BETHLEHEM STEEL CO., *General Offices,* BETHLEHEM, PA.
District Offices: New York, Boston, Philadelphia, Baltimore, Washington, Atlanta, Pittsburgh, Buffalo, Cleveland, Cincinnati, Detroit, Chicago, St. Louis.
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"PENNSYLVANIA" *STEELBUILT*
COAL BREAKERS AND CLEANERS (Bradford Type)
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"Pennsylvania" *STEELBUILT* Coal Preparation Machinery offers engineers and operators a wide selection of types and sizes, specialized for heavy, continuous service in Central Stations, Gas Works and industrial Power Plants.

POSITIVE TRAMP IRON PROTECTION
UNBREAKABLE STEEL CONSTRUCTION

Put your coal preparation problems up to us

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General Offices: Liberty Trust Bldg., Philadelphia
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UNIPULVO
UNDERFED UNIT FUEL PULVERIZER

For all boilers—150 H. P. up, using any bituminous coal, lignite, petroleum coke, pitch or charcoal.

THE STRONG-SCOTT MFG. CO.
Minneapolis, Minnesota

MORSE

Silent Chain Drives Give Trouble-Free Operation

MORSE CHAIN CO., ITHACA, N. Y.
Manufacturers of Morse Silent Chain Drives, Flexible Couplings and Chain Speed Reducers.
BRANCHES IN PRINCIPAL CITIES

Read what F-M Diesels are doing *in plants like yours!*

Do you know the savings modern Diesel Engines are making in plants such as yours? Do you know that each year sees an impressive addition to Fairbanks-Morse Diesel horsepower in industrial service—and why?

A new booklet, just published, gives important engineering data on these engines in all types of service, large and small. The engineer responsible for power production should read it. From it you may get an important cost-cutting idea. You can have a copy without obligation. Mention Bulletin No. 3010 in your letter.

FAIRBANKS, MORSE & CO.
900 S. Wabash Ave., Chicago
32 branches at your service throughout the United States

FAIRBANKS-MORSE DIESEL ENGINES
THE 80-hp. F-M Diesel eliminated demand charges on electric welding machines and effected immediate savings for the Peerless Pressed Metal Corp. of Watertown, Mass.
THE manufacturing plant of Chappel Bros., Rockford, Ill., receives power from the above 360-hp. F-M Diesel.
THE 240-hp. F-M Diesel, shown at the right, replaced a steam plant in the Andrews Grain Co. Elevator, the oldest one in Minneapolis, and has very materially reduced operating costs.
ECONOMY OF DIESEL ENGINE POWER
THE Foote Gear Works of Chicago effected marked savings in power cost by the installation of a 130-hp. F-M Diesel to operate their factory.
THESE three 360-hp. F-M Diesel electric generating units are supplying power to the Hotel Commodore, New York. This installation replaced purchased power, and the question of "on" peak hours is practically eliminated.
$4,000.00 per year was saved by installing this 120-hp. F-M Diesel in the plant of the Mitchell Battery Co., St. Paul, Minn.
FAIRBANKS-MORSE DIESEL ENGINES
ECONOMY OF DIESEL ENGINE POWER
BULLETIN No. 3010

FAIRBANKS-MORSE
DIESEL ENGINES
POWER, PUMPING AND WEIGHING EQUIPMENT

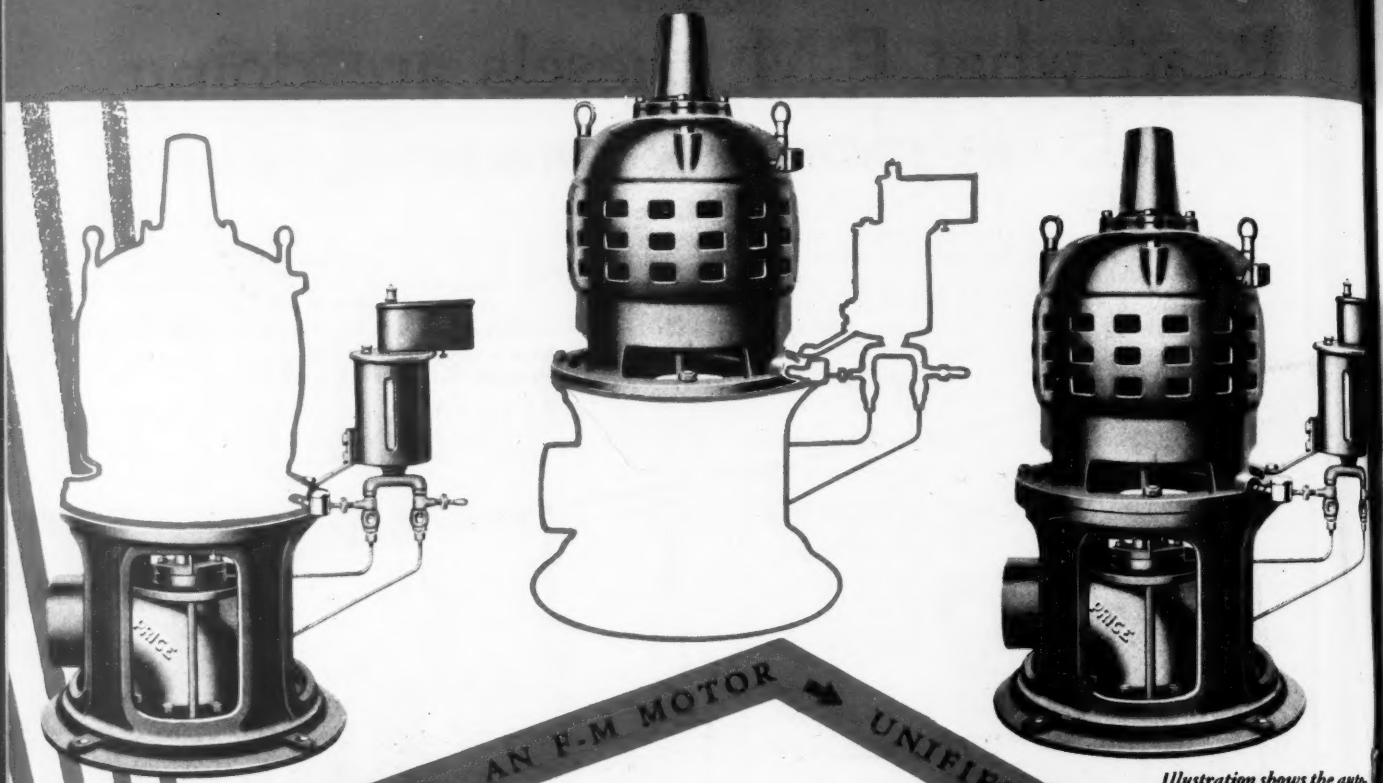

Illustration shows the automatic, solenoid-operated lubricator furnished if desired.

AN F-M PUMP ➡ AN F-M MOTOR ➡ UNIFIED RESPONSIBILITY

BE CAREFUL when you buy a turbine pump. Know the maker. Find out how he is equipped to render service. Consider his guaranties. Is he solely responsible, and to what extent?

If you purchase a Fairbanks-Morse Price-Turbine Pump, you have the assurance that a world-known organization manufactured *both* the pump and the motor. You know they have been designed and balanced to work as a single unit. You accept a single guarantee and hold a single source solely responsible. And if in years to come, service should be required—there are 32 branches and service stations, one of them just a short distance away, with complete facilities for service.

The complete story of the design and manufacture—the service and guaranties—explains why a purchase of this pump unit is a *protected* investment. May we send it?

FAIRBANKS, MORSE & CO.
900 S. Wabash Ave., Chicago
32 branches at your service throughout the United States

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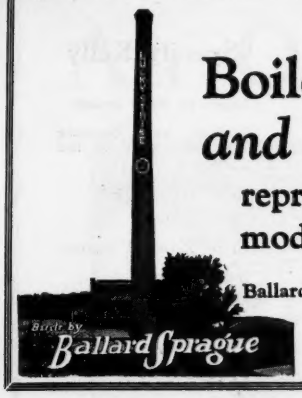
FAIRBANKS-MORSE
PUMPS & MOTORS
POWER, PUMPING AND WEIGHING EQUIPMENT



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Boiler Settings and Chimneys
represent the best modern practice

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25 East 26th Street
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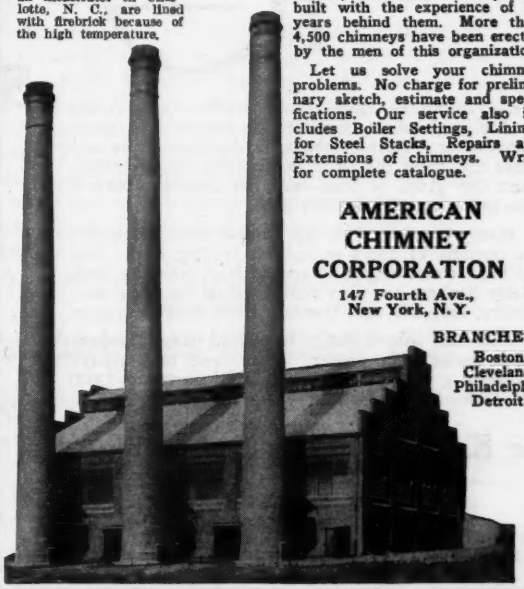
CHIMNEYS

Brick and Concrete — Cement Gun Work

BOILER SETTINGS
COMPLETE POWER PLANTS
THE RUST ENGINEERING CO.
PITTSBURGH, PA.
CHICAGO NEW YORK WASHINGTON BIRMINGHAM

AMERICAN

Chimneys — Boiler Settings
correct! strong! permanent!



These American Chimneys, 125' x 5', serving an incinerator in Charlotte, N. C., are lined with firebrick because of the high temperature.

Scientifically designed and built to withstand the most severe service, American Chimneys are built with the experience of 27 years behind them. More than 4,500 chimneys have been erected by the men of this organization.

Let us solve your chimney problems. No charge for preliminary sketch, estimate and specifications. Our service also includes Boiler Settings, Linings for Steel Stacks, Repairs and Extensions of chimneys. Write for complete catalogue.

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Riley Stoker Corporation

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9 Neponset Street, WORCESTER, MASS., U. S. A.

"RILEY" Underfeed Stokers
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Pulverized Coal Installations

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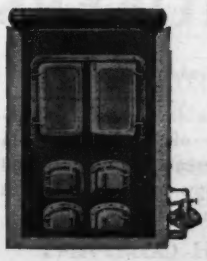
BURNERS
for
Oil — Pulverized Coal — Gas

PEABODY

Our bulletin 601 contains valuable information. Send for it.

Peabody Engineering Corporation
295 Madison Ave. New York

Wing Forced Draft Blowers
Motor — or Turbine — Driven



for making
MORE STEAM
MORE QUICKLY
MORE CHEAPLY
in boilers
Stokered or Hand-Fired

Ask for Bulletin

L. J. Wing Mfg. Co.
156 W. 14th St., New York, N.Y.

Review Year's operation and find fuel bills cut 10 to 15% *with* KELLY IMPROVED HAND STOKERS

Kelly Improved Hand Stokers effect big savings in fuel and labor, consistently, and with a small investment. These stokers, in designs, styles and sizes that meet the latest combustion requirements, burn any grade of coal, even the cheapest, burn it smokelessly and keep hot fires.

Manipulated entirely by outside levers, requires no opening of doors except for feeding coal. Due to their construction of special heat-resisting iron, Kelly Stokers are also distinguished for their durability, long life, and freedom from repair expense.

Why not install Kelly Improved Hand Stokers right under your present boilers and be prepared to show a saving in fuel and labor costs for 1930! Write for information.

Specify Kelly

Improved Hand Stokers

Rocking and Dumping Grates — Style A and Style B

Portable Kiln Grates

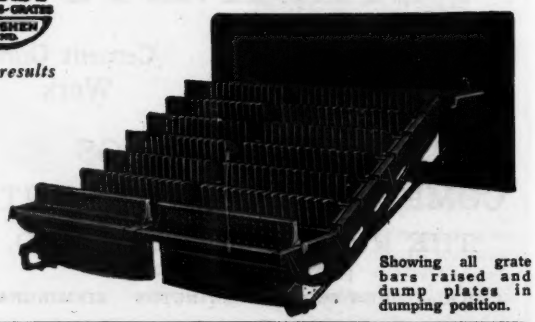
Circle Grates

Grate Bars—all patterns

Boiler Fronts

When you buy KELLY STOKERS-GRATES GOSHEN IND. *you buy results*

Easy to operate
Easy to install



Showing all grate bars raised and dump plates in dumping position.

The Kelly Foundry & Machine Co.
617 Ninth Street, Goshen, Ind.
POWER PLANT ENGINEERS
Established 1887
NEW YORK OFFICE: 53 Park Place — CHICAGO OFFICE: 178 W. Adams St. — PHILADELPHIA OFFICE: Bourse Bldg.

TAYLOR STOKER

Economical, efficient. Burns coal as it comes from the mine. Obtains maximum capacity from boilers.

AMERICAN ENGINEERING Company
2408 Aramingo Ave., Philadelphia

Huber Type "MH" Stoker

HUBER STOKERS

A Stoker for Every Boiler

Write for interesting records of performance in representative plants, and a copy of "Five Minutes With the Coal Bill".

FLYNN AND EMRICH COMPANY
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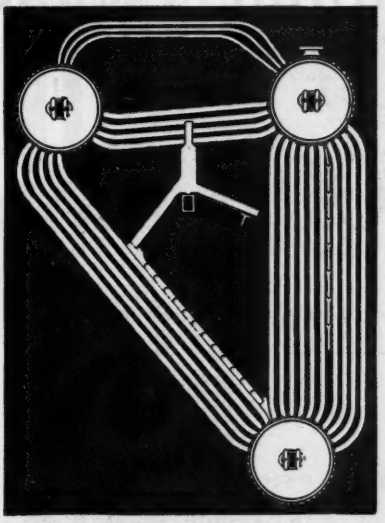
DETROIT UNDERFEED STOKERS

for every service

Detroit Stoker Company
General Motors Bldg - Detroit.

An Outstanding Design—



Among bent tube boilers now offered by manufacturers the three drum type has become increasingly popular. Among three drum boilers, the Wickes Design has been firmly established by the proven performance of actual installations.

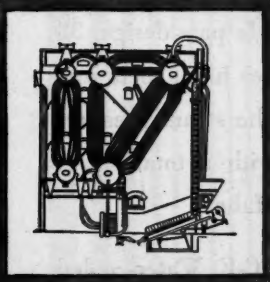
The simple arrangement of drums and tubes makes possible easy accessibility to both fire and water sides of the heating surface. Positive circulation delivers water to the tubes at all ratings. Steam carrying tubes in a high temperature zone deliver superheated steam to the nozzle outlet. Tight baffling prevents gas short circuiting and therefore promotes maximum heat absorption. These are but a few of the advantages which have made the Wickes Three Drum Boiler a successful unit in daily operation.

Descriptive Literature Gladly Sent on Request.

THE WICKES BOILER CO.
Est. in 1856
SAGINAW, MICHIGAN
SALES OFFICES:
New York, 501 Fifth Ave. Detroit, 2357 Union Trust Bldg.
Pittsburgh, 1218 Empire Bldg. Chicago, 33 S. Clark St.

WICKES THREE DRUM BOILERS

THE PIONEER OF 3-DRUM BOILERS



The ERIE CITY 3-DRUM BOILER has an impressive background of industrial acceptance

ERIE CITY IRON WORKS, Erie, Penna.

NEEMES

Neemes Improved Shaking and Dumping Grates have for 56 years been the choice of careful and discriminating buyers because any kind of coal can be burned on them with the best possible combustion.

NEEMES FOUNDRY, INC.
196 First Street Troy, N. Y.
Manufacturers of Round and Square Grates and Fully Automatic Stokers
Established 1874

ECONOMY QUALITY 1874 NEEMES SERVICE

GRATES

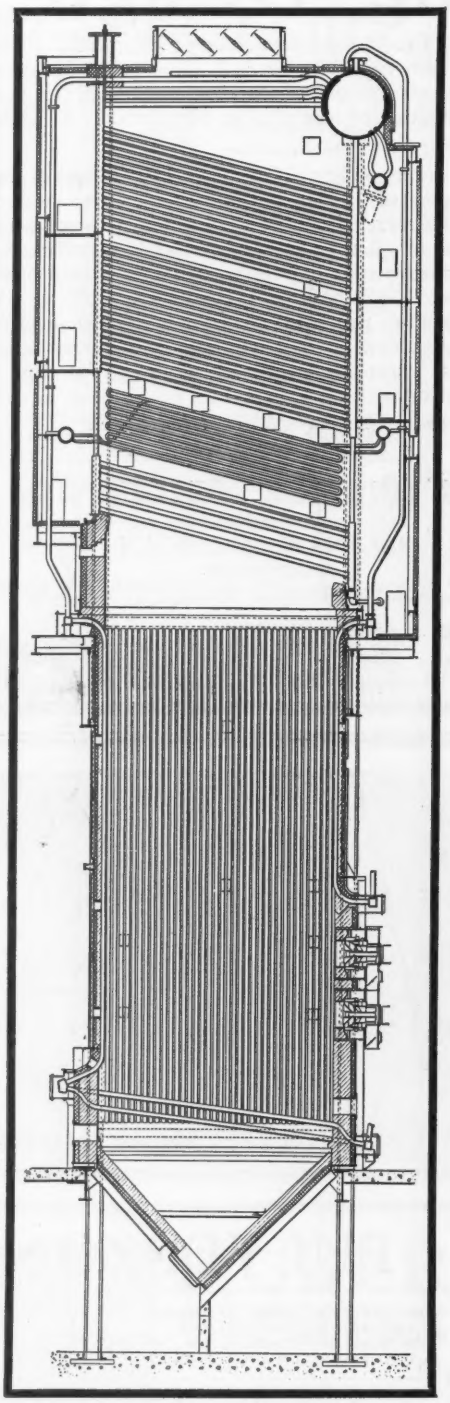
PULVERZONE

PULVERIZED COAL BURNING
AUTOMATIC STOKER FIRING
AUTOMATIC COMBUSTION CONTROL
AUTOMATIC DAMPER REGULATION
} COMBINED IN A SIMPLE UNIT

CUTS COAL COSTS 15 TO 60%
REDUCES LABOR 50 TO 75%

PULVERZONE AUTOMATIC COAL BURNING SYSTEM
Division of COKAL STOKER CORPORATION
Wrigley Building, Chicago, Illinois

One Walsh-Weidner Forged Steel Sectional Header Boiler *to serve a* 25,000 kw. Generator



Sectional elevation of the Combustion Engineering steam generating unit now under construction at the Duluth Steam Electric Station of the Minnesota Power & Light Company.

The Walsh-Weidner sectional header boiler to be installed at the Duluth Steam Electric Station of the Minnesota Power & Light Company is believed to be the largest sectional header boiler ever built.

This Walsh-Weidner forged steel sectional header boiler contains 36,300 sq. ft. of heating surface; is of single pass design, 38 sections wide and 43 tubes high, including 3 rows of circulators. The steam pressure is 485 lb. per sq. in. with a total steam temperature of 760 deg. fahr.

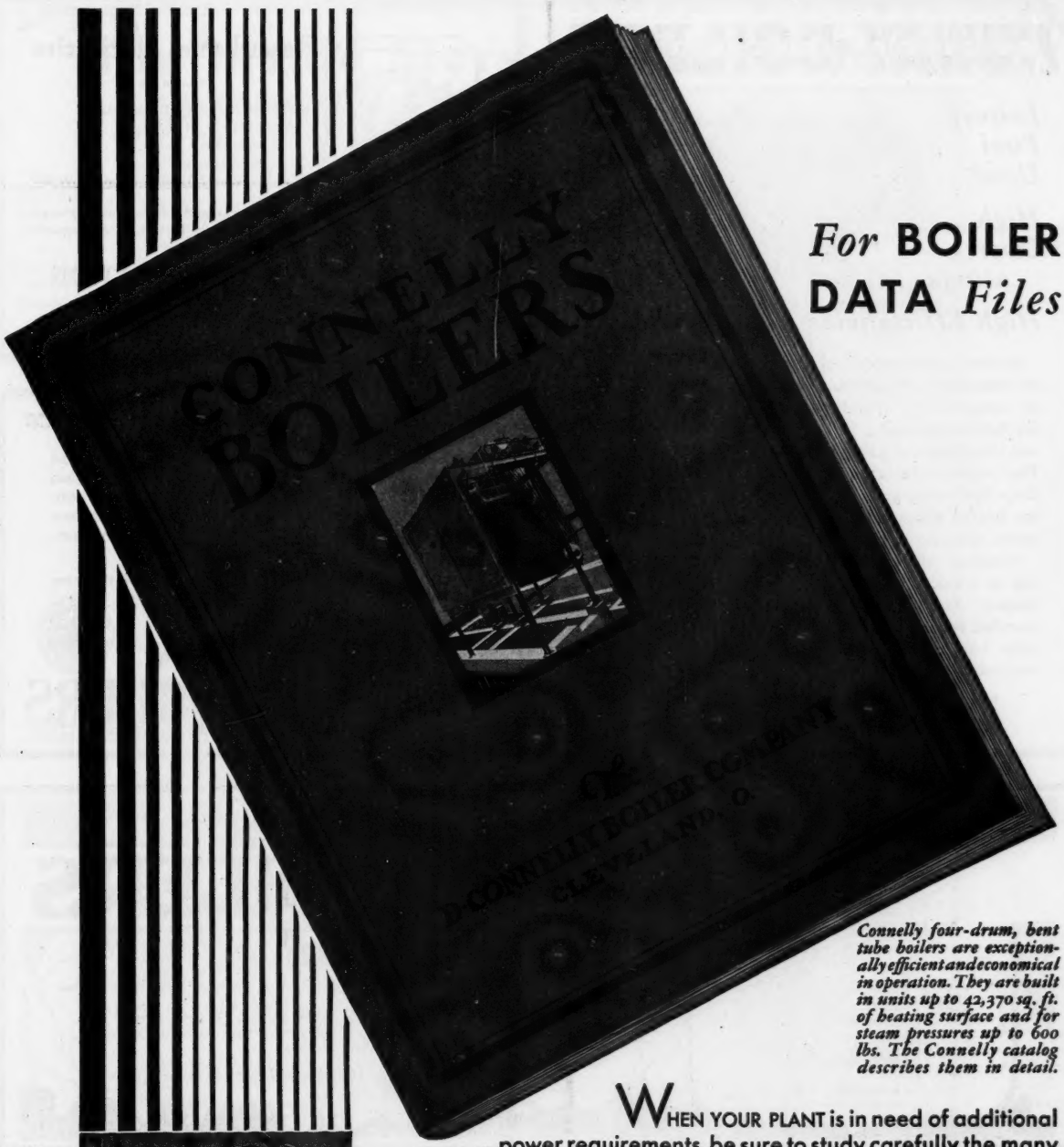
The furnace is of the C-E Water-cooled wall construction and pulverized fuel is introduced through six Lopulco horizontal burners.

This installation is an excellent example of the rapidly growing trend of—one boiler per generator.

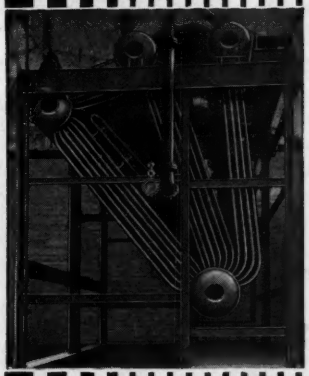
COMBUSTION ENGINEERING CORPORATION

200 MADISON AVENUE NEW YORK, N. Y.

BOILERS - AIR PREHEATERS - STOKERS - PULVERIZED FUEL EQUIPMENT - WATER-COOLED FURNACES



Connelly four-drum, bent tube boilers are exceptionally efficient and economical in operation. They are built in units up to 42,370 sq. ft. of heating surface and for steam pressures up to 600 lbs. The Connelly catalog describes them in detail.



For BOILER DATA *Files*

WHEN YOUR PLANT is in need of additional power requirements, be sure to study carefully the many features of Connelly boiler construction . . . submerged upper front drum, steam drying tubes, simplicity of construction, two-point suspension, unrestricted water circulation, large overload capacity, etc., ... that assure the highest possible efficiency at the lowest cost of operation. There is a type of Connelly boiler that will meet exactly your power requirements. A catalog describing its construction features in detail will be sent promptly at your request.

THE D. CONNELLY BOILER COMPANY
1170 IVANHOE ROAD · CLEVELAND, OHIO

Pacific Coast licensees: Consolidated Steel Corporation, Los Angeles
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CONNELLY BOILERS

BOILER SPECIALISTS FOR 55 YEARS

NUWAY BOILERS
CONTROLLED CIRCULATION

Lowers Fuel Used

High Over-atings

High Efficiencies

"As Others See Us"

Nuway performance is based on controlled circulation. Water is compelled to travel through the heating passages in the correct direction and at rapid speed. This increases better heat absorption. The water goes up between the heated tubes and down between non-heated plates.

"Consult Nuway before you buy or specify." Where space is limited, Nuway Boilers can be installed to give the greatest possible horsepower in the space available.

Read what The West Suburban Hospital Association wrote to us: "Since installing the Nuway 175 hp. boiler (72" x 16') . . . we are pleased to report that our monthly evaporation shows over 9 lb. from and at 212 deg. F. as fired, burning Illinois and Eastern Kentucky screenings. During the severe weather this boiler operates up to 400 hp. continuously . . . When this boiler is shut down for cleaning we use three 66" x 18' standard H. R. T. boilers to do the same work using considerable more fuel."

NUWAY BOILER & ENGINEERING CO.
333 North Michigan Ave., Chicago

Remarkable Efficiencies

Shown by

BADENHAUSEN (Patented)
BOILERS
Preheaters
Superheaters
Water Cooled Furnace Walls

Each a unit in itself, yet an integral part of the boiler proper
Surveys and Tests by outside Engineers forwarded on request

BADENHAUSEN CORPORATION
General Office and Works
Cornwells Heights, Bucks County, Pa.

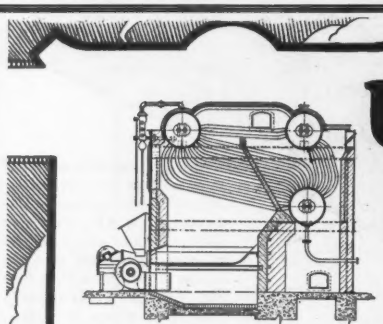
Water Tube Boilers for Every Service

BOILERS of high quality for central stations and industrial plants of all sizes, and for utilization of waste heat from kilns and furnaces. Steel construction only. Straight tube and bent tube types. Noted for long life and economy of operation.

Engineering service available—wire or write.

EDGE MOOR IRON COMPANY Edge Moor, Delaware

EDGE MOOR Water Tube BOILERS
STRAIGHT AND BENT TUBE TYPES—WATER WALLS—AIR PREHEATERS



UNION TYPE E BOILERS
CAPACITY EFFICIENCY

a modification of the standard UNION 3-drum vertical bent tube boiler
FOR RESTRICTED SPACE INSTALLATIONS
—UNRETARDED CIRCULATION—FREE STEAM LIBERATION—DRIER STEAM—NO INACTIVE HEATING SURFACES

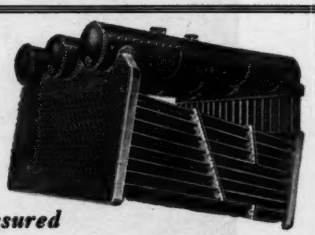
UNION IRON WORKS
ERIE, PA

SPRINGFIELD
BOILERS—WATER WALLS
SECTIONAL—ALL STEEL
ALL SIZES—ALL PRESSURES

Repeat orders constitute the largest part of our business

SPRINGFIELD BOILER CO.
SPRINGFIELD, ILLINOIS

Murray Water-Tube Boilers



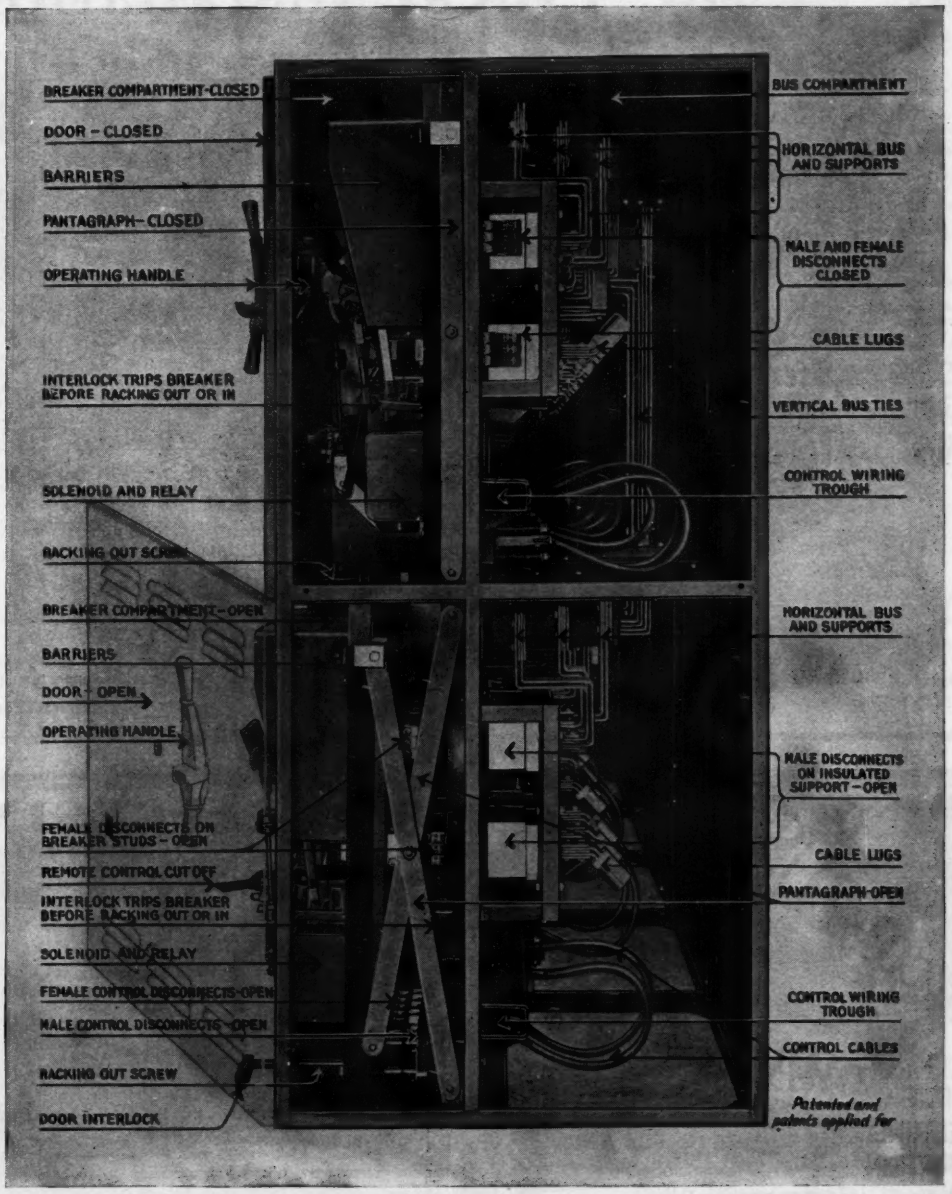
Steam Economy Assured

Incorporated in 1870, the Murray Iron Works Co. is one of the oldest builders of steam power equipment in the country. Specializing in boilers, engines and turbines, this company is prepared to help you to save fuel and to lower production costs. Send for complete information on Murray Products.

Murray Iron Works Co., Burlington, Iowa

The Inside Story of the Multumite

"The World's Largest Builders of Air-Type Circuit Breakers"



"The World's Largest Builders of Air-Type Circuit Breakers"

This is a Multumite-Hingite group mounting ten solenoid operated U-Re-Lites of 1250 amperes capacity at 440 volts, 3 phase, 60 cycles. Multumite groups are also made without the double disconnects (Rigite construction) and with hand operated U-Re-Lites mounted from two to six high, according to capacity.

Get in touch with our nearest representative for data on a Multumite group to meet your requirements.

I-T-E CIRCUIT BREAKER COMPANY, 19th and HAMILTON STS., PHILADELPHIA

Birmingham, Crawford Bldg.; **Boston**, 201 Devonshire; **Buffalo**, Ellicott Sq. Bldg.; **Chicago**, 333 N. Michigan Ave.; **Cincinnati**, Union Trust Bldg.; **Cleveland**, Terminal Tower Bldg.; **Denver**, Tramway Bldg.; **Detroit**, Penobscot Bldg.; **Duluth**, Providence Bldg.; **Kansas City**, Midland Bldg.; **Los Angeles**, 106 W. 3rd; **Minneapolis**, Plymouth Bldg.; **Montreal**, 151 Lagauchetiere St. West; **New Orleans**, 708 Girod St.; **New York**, 12 E. 41st St.; **Omaha**, Electric Bldg.; **Philadelphia**, 1505 Race; **Pittsburgh**, Grant Bldg.; **St. Louis**, Bank of Commerce Bldg.; **San Francisco**, Call Bldg.; **Seattle**, 802 33rd Ave.; **Toronto**, 149 Adelaide St. E.; **Vancouver**, 500 Beatty Street; **Winnipeg**, National Cartage Office Building.

I-T-E PROTECTION

U-RE-LITES ~ ~ I-T-E CIRCUIT BREAKERS

One of the Finest Installations

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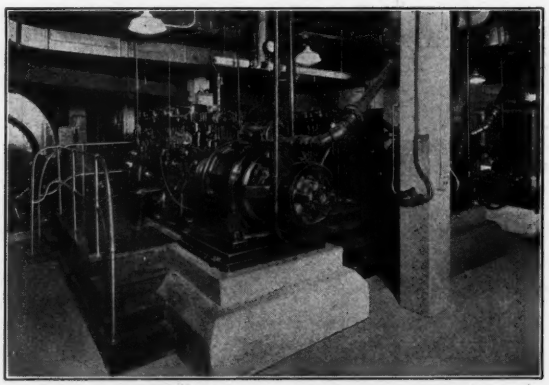

Two 120 K.W. G.E. generators each direct connected to straight 8 cylinder 240 H.P. 1200 R.P.M. Sterling engine. Supplies power for lights and elevators when main current fails.

Sterling High Duty — **Internal Combustion Engines**

Sterling — The Engine of Refinement

12 to 565 B.H.P. Gas or gasoline

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Branches in all Principal Cities

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Vertical Single Acting { 2 Cycle . . . Solid Injection / 4 Cycle . . . Air Injection
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GAS ENGINES	CHROMIUM PLATING

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WORTHINGTON PUMP AND MACHINERY CORPORATION
Works at Harrison, N. J., Cincinnati, Ohio, Buffalo, N. Y., Holyoke, Mass.
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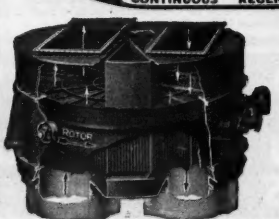
Reg. U.S. Pat. Off.

CONTINUOUS REGENERATIVE COUNTERFLOW



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Air Preheater Corp., 40 E. 34th St., New York

WACHS Fully Enclosed and Self-Oiling Engines

for Driving Stokers, Fans, Pumps, etc.

These Engines are the result of over 47 years of experience in engine building and over 10,000 of them are reliably serving many of the most modern industrial power plants and central service stations all over the country. Every moving part of the engine is automatically oiled. Force feed cylinder lubrication is standard equipment. All moving parts, including the entire valve motion, are completely enclosed. Large cover plates, having machined joints, give accessibility to the various parts for adjustment. Stuffing boxes are provided to prevent the exit of oil or the entrance of foreign matter.

Wachs Engines are Fully Enclosed and Self Oiling.

Write for details.

THE E. H. WACHS CO.
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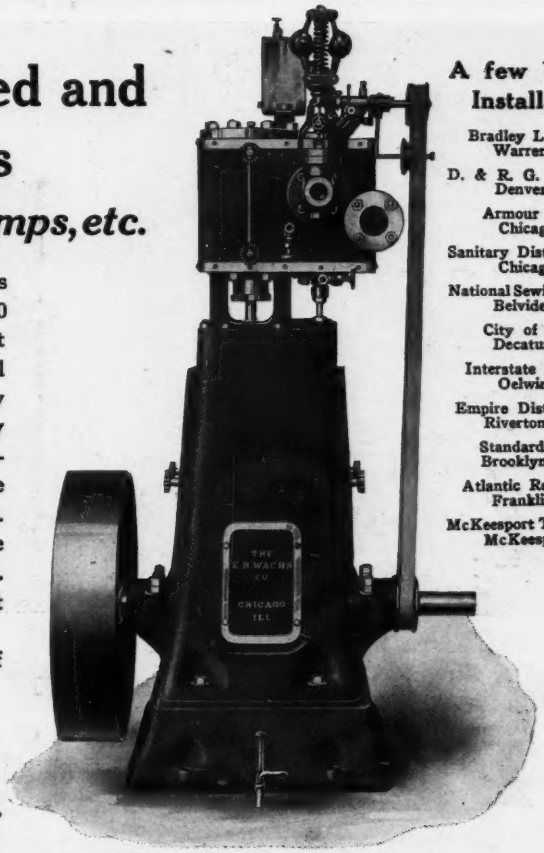

A few WACHS Installations.

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Armour and Co. Chicago, Ill.
Sanitary Dist. of Chicago Chicago, Ill.
National Sewing Mach. Co. Belvidere, Ill.
City of Decatur Decatur, Ind.
Interstate Power Co. Oelwine, Ia.
Empire Dist. Elec. Co. Riverton, Kans.
Standard Oil Co. Brooklyn, N. Y.
Atlantic Refining Co. Franklin, Pa.
McKeesport Tin Plate Co. McKeesport, Pa.

De Laval 50 hp. steam turbines using steam at 140 lbs. and exhausting against 30 lbs. back pressure and each driving two De Laval pumps. One pump handles 1500 gals. per min. of cooling water against 70 ft. head and the other 52 gals. per min. of 0.77 sp. gr., 90° F. gasoline against 50 lbs. There are five such units in this plant.

SINGLE RESPONSIBILITY In Pumping Units

De Laval steam turbines and centrifugal pumps are designed, built, guaranteed and tested complete in one plant under the direction of one staff of engineers. That is one of the reasons why they give such uniformly satisfactory results.

De Laval Steam Turbine Co.
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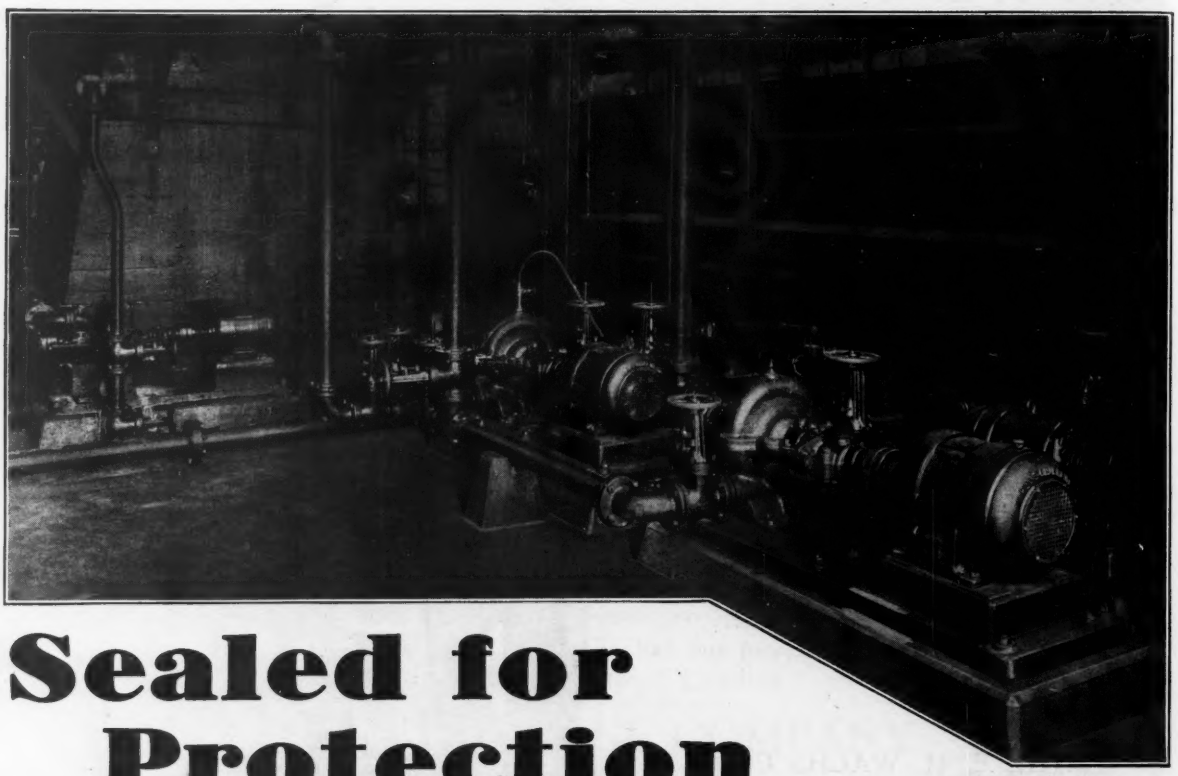
Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Flexible Coupling, Double Helical Speed Reducing Gears, Worm Gears, Hydraulic Turbines and Special Centrifugal Machinery. 3052



Sealed for Protection

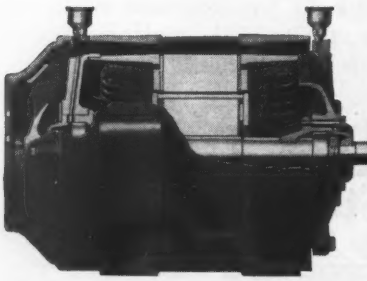
against corrosive gases and liquids

One 5 h.p. and two 15 h.p. (1730 r.p.m.) Type ARZ Motors operating Allis-Chalmers centrifugal pumps, handling brine in an Electro-Chemical plant.

Corrosive moisture and gases, often present in chemical plants, cannot harm Allis-Chalmers totally enclosed fan-cooled motors because the windings of these motors are thoroughly sealed from contact with the outside air.

Because of this protection against harmful corrosives, dust and dirt, the motors may be installed in out-of-the-way places with very little attention except periodic greasing—thus eliminating frequent and expensive inspection, cleaning and repairs.

And this protection is accomplished by a simplified design that includes no rubbing or revolving seals and that provides accessibility equal to that of the standard open type motor.



ALLIS-CHALMERS

Totally Enclosed Fan-cooled MOTORS

Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

ON THE TEST FLOOR . . .

DE LA VERGNE FOUR-CYCLE SOLID INJECTION DIESELS

This photograph shows a group of De La Vergne Diesel Engines undergoing test prior to shipment during the week of October 12.

A total of 4240 brake horsepower in sizes of 1200 to 240 per unit.

I. P. MORRIS AND DE LA VERGNE, INC.
Richmond and Norris Street
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Steam engine drives solve the problem of lower power cost . . . . . .

Steam engines, exhausting against back pressure into process and heating systems operate on a more efficient working cycle than condensing units.

Power is delivered as a by-product at an almost negligible cost, since most of the heat is recovered from the exhaust steam, instead of being lost in the condenser discharge.

The moderate operating speed is an asset that especially adapts steam engines to drive—

GENERATORS
EXCITERS
FANS
EXHAUSTERS
BLOWERS
STOKERS
PULVERIZERS
PUMPS
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ROTARY DRIERS
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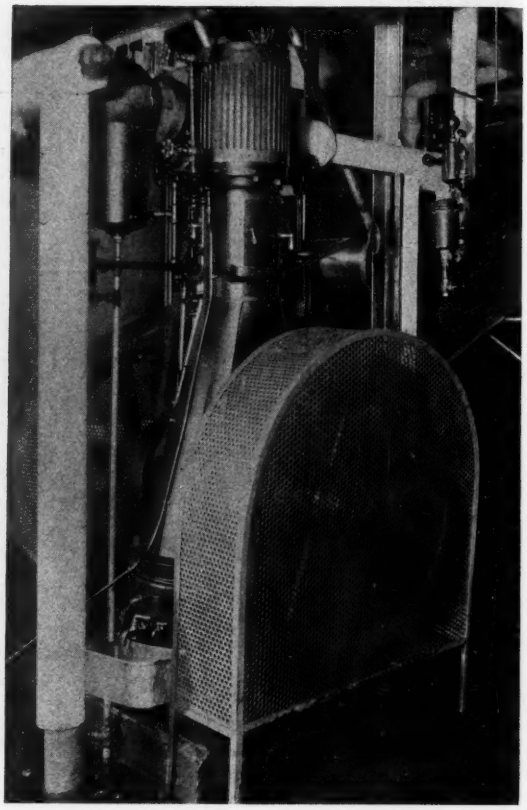
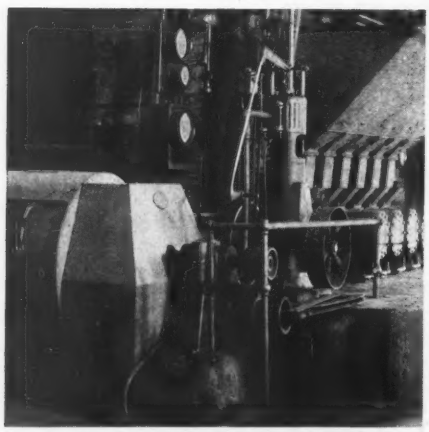


Troy Self-Oiling Steam Engine driving line shaft at Twin City Milk Products Association, St. Paul, Minn. The exhaust from the engine is used for heating air for drying milk.



Troy Self-Oiling Steam Engine driving stokers at the municipal power plant, City of Prince Albert, Saskatchewan, Canada.

TROY SELF-OILING STEAM ENGINES are built horizontal and vertical in capacities to 225 brake horsepower with single cylinder and to 450 brake horsepower in the duplex type. The self-compensating balanced flat valve which automatically drains the cylinder combines safety with low steam consumption.

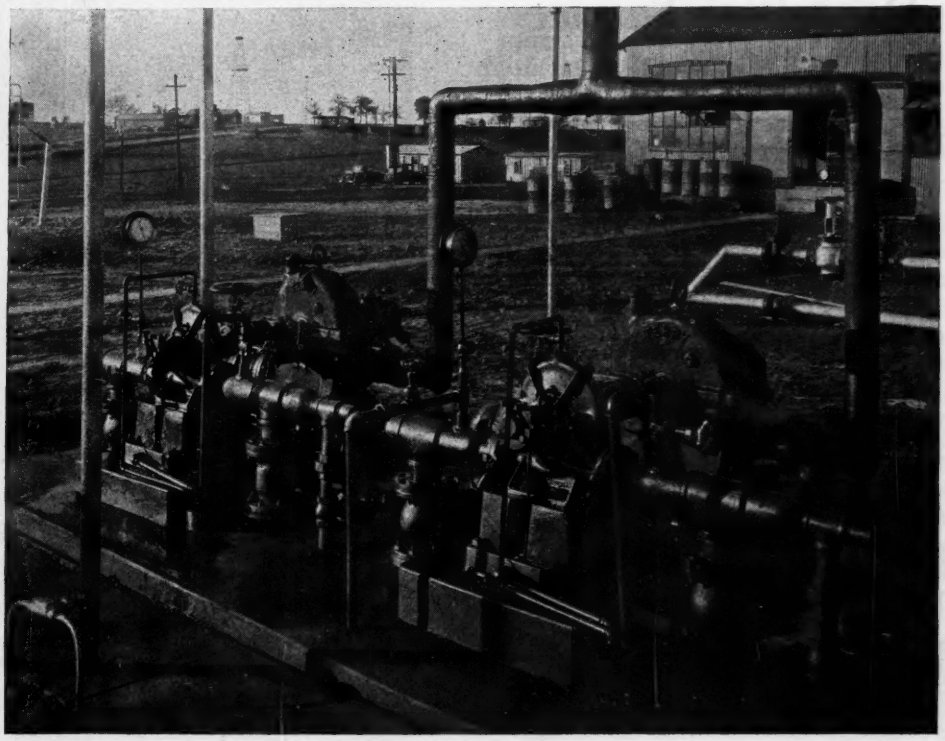
ENGBERG SELF-OILING STEAM ENGINES are built vertical only in capacities to 100 brake horsepower with single cylinder or to 200 brake horsepower in the twin type. The engines have a balanced piston valve which operates in a renewable liner.

TROY-ENGBERG GENERATING SETS are designed for high efficiency, for main unit, booster or standby service. Built two or three wire for direct current in ratings 3½ to 150 kw. and for alternating current in ratings 5 to 187½ kva., for all commercial voltages to 2300.

Write for catalogs and detailed information desired.

Troy Engine & Machine Co., Troy, Penna.

TERRY



STURDY TURBINE CONSTRUCTION

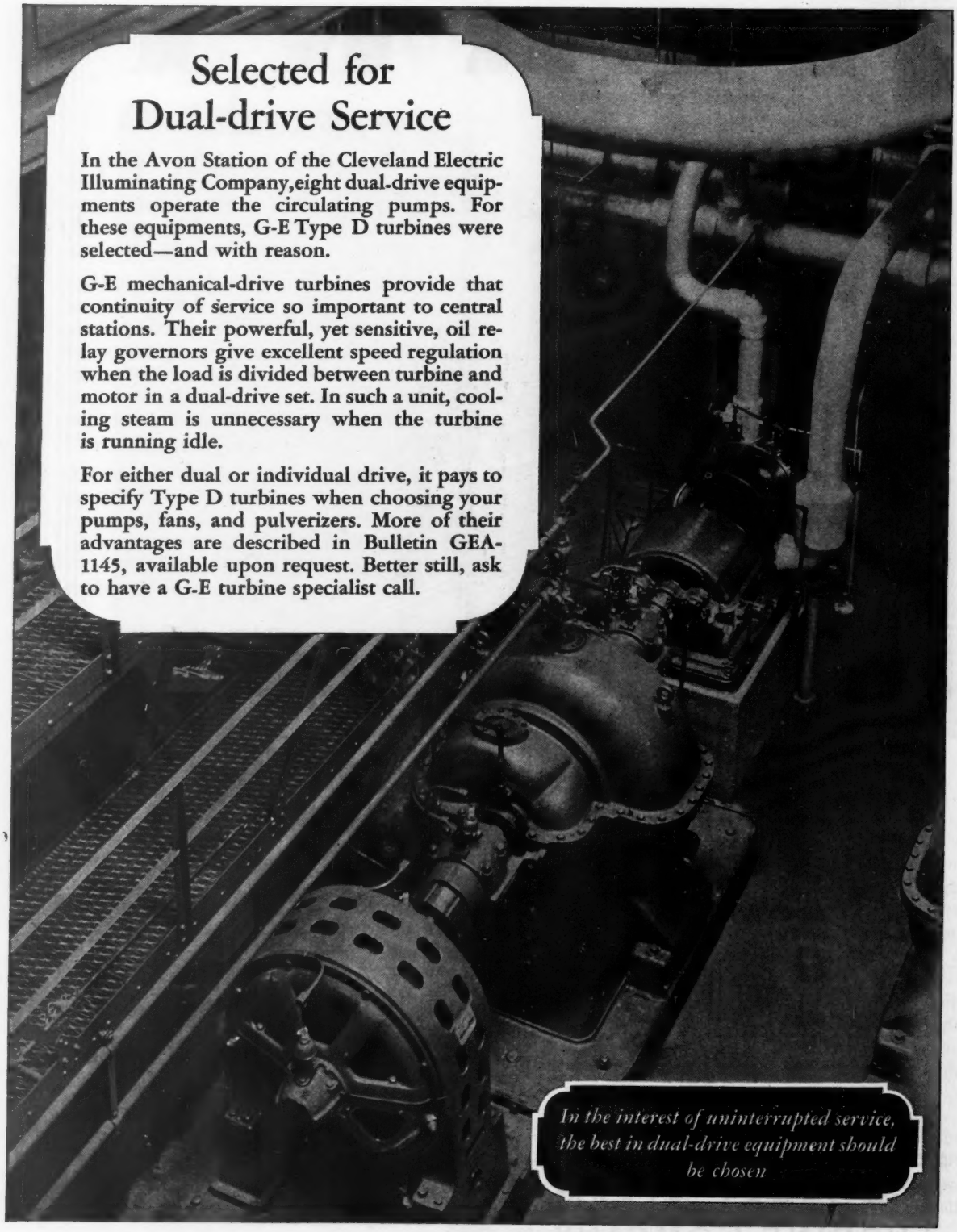
The two Terry Wheel Turbines shown above are serving a mid-continent oil refiner.

They are equipped with one-piece steel rotors. The turbine buckets are milled from the solid metal. There are no parts to work loose.

Such sturdy construction makes for long life and low maintenance costs.

The TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.
Steam Turbines - Gears - Shaft Couplings

T-1059



Selected for Dual-drive Service

In the Avon Station of the Cleveland Electric Illuminating Company, eight dual-drive equipments operate the circulating pumps. For these equipments, G-E Type D turbines were selected—and with reason.

G-E mechanical-drive turbines provide that continuity of service so important to central stations. Their powerful, yet sensitive, oil relay governors give excellent speed regulation when the load is divided between turbine and motor in a dual-drive set. In such a unit, cooling steam is unnecessary when the turbine is running idle.

For either dual or individual drive, it pays to specify Type D turbines when choosing your pumps, fans, and pulverizers. More of their advantages are described in Bulletin GEA-1145, available upon request. Better still, ask to have a G-E turbine specialist call.

In the interest of uninterrupted service, the best in dual-drive equipment should be chosen

175-28

GENERAL ELECTRIC

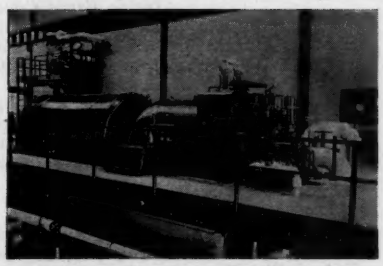
SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

165,000 kw. IN SERVICE

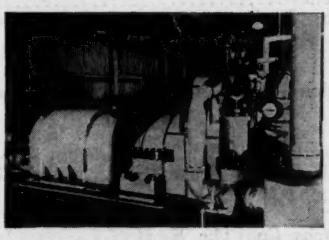
TO UP

with facilities to build any size . . .

Above—The 165,000-kw. cross-compound Westinghouse Turbine-Generator Unit installed at Hell Gate Station.



A 10,000-kw. Westinghouse Turbine-Generator Unit installed at the Mountain States Power Company, Coos Bay, Oregon.



The 1,000-kw. Westinghouse Turbine-Generator Unit installed at the Deming Ice and Electric Company, New Mexico.

TURBINES built by Westinghouse embrace a variety of types and sizes to meet any demand. Units now installed and in successful operation range in size from one kw. to 165,000 kw. —each built to fit its own special application — properly designed, installed, and serviced to provide the maximum efficiency and reliability.

Back of every Westinghouse turbine are years of experience, complete manufacturing facilities, and extensive engineering resources. These factors are your guarantee for its economical and dependable performance.

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Service, prompt and efficient, by a coast-to-coast chain of well-equipped shops

Westinghouse

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